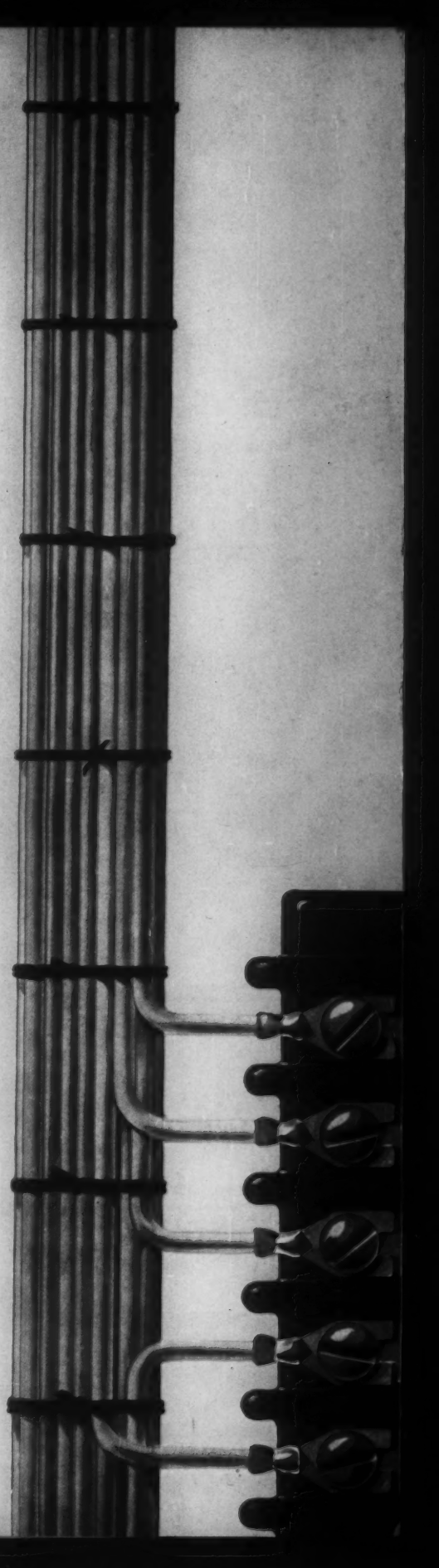
JULY 9, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Cable Design for Wired Equipment

Contents, Page 3

FARNSWORTH

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The same courteous prompt service by bearing experts go into every order at Bound Brook's newly expanded production facilities. There is no penalty for small orders — regardless of quantity.

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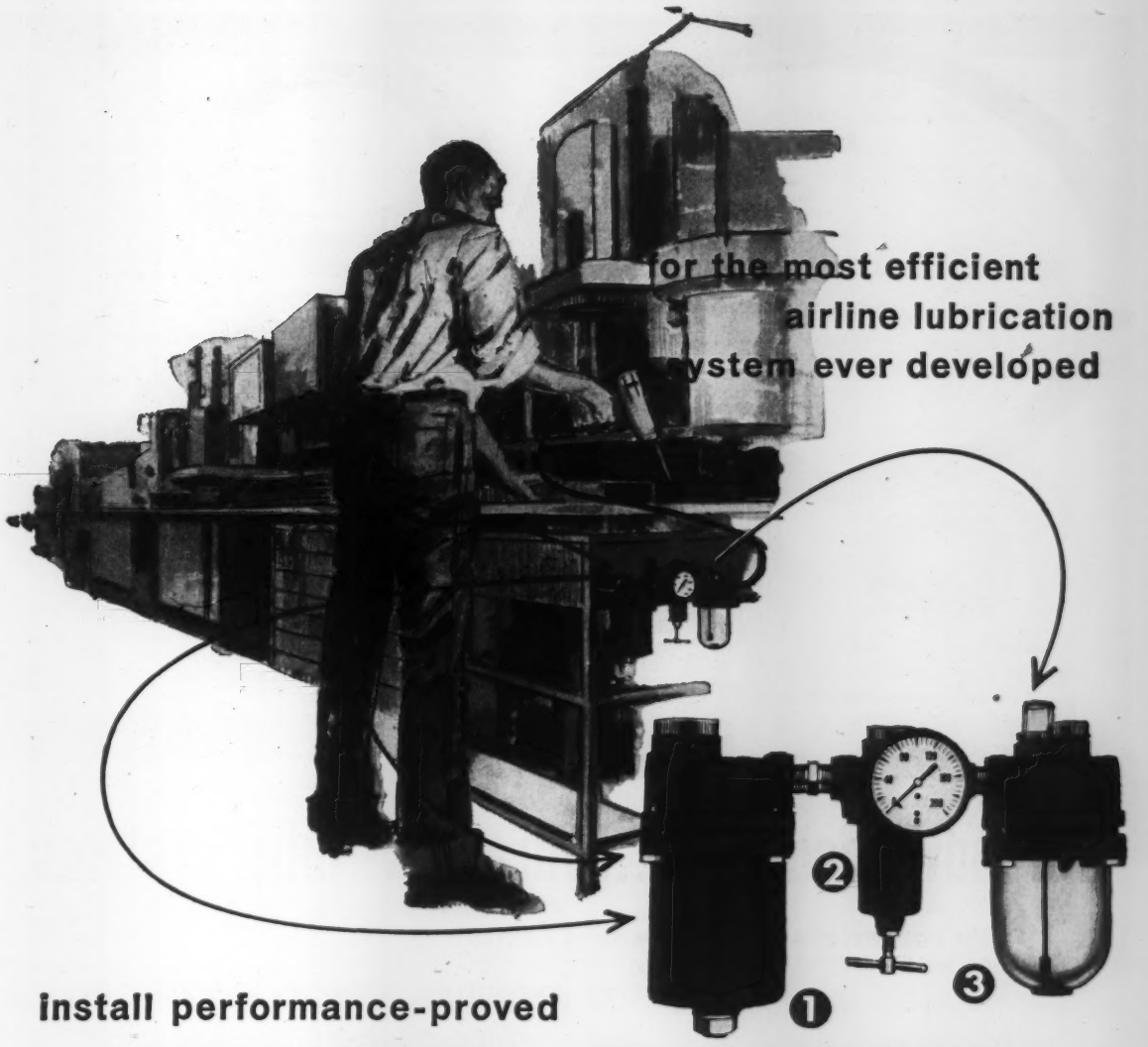

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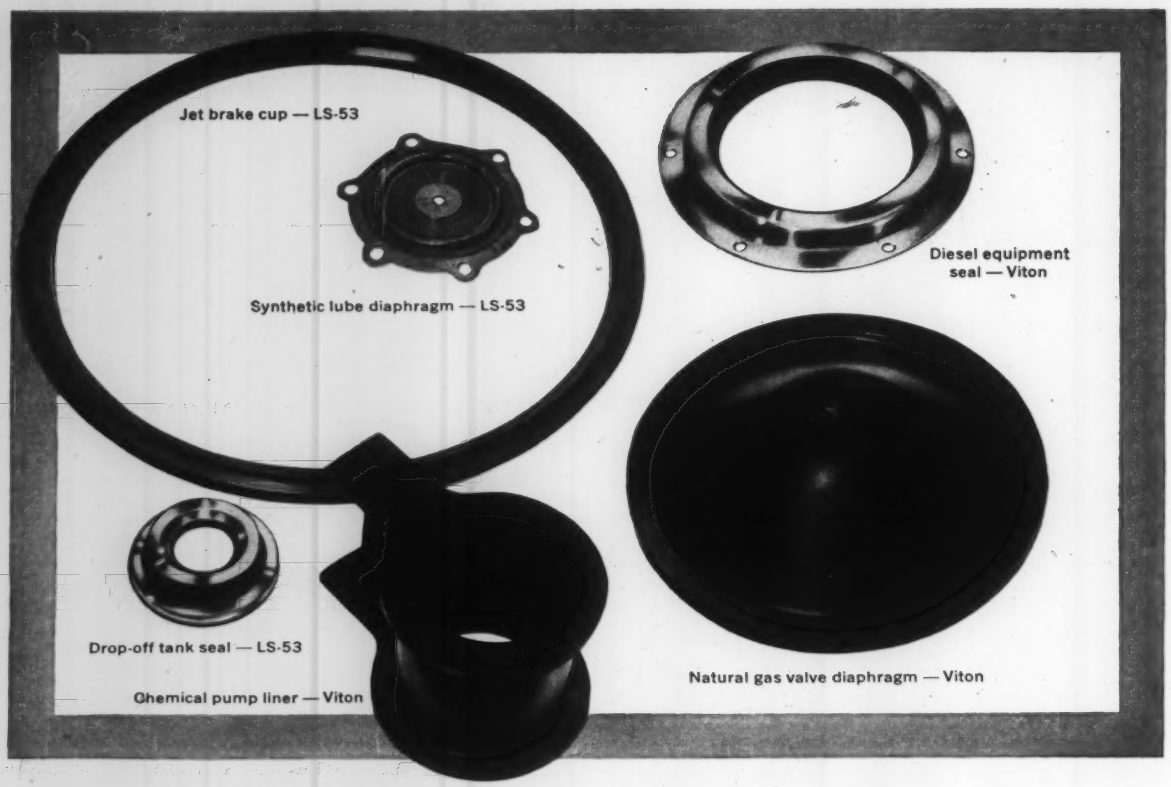
Jet brake cup — LS-53
Synthetic lube diaphragm — LS-53
Diesel equipment seal — Viton
Drop-off tank seal — LS-53
Chemical pump liner — Viton
Natural gas valve diaphragm — Viton

For advanced fuel...hydraulic...lube systems,

New materials prove ideal in handling temperature extremes −350° F. to +750° F.

Working with two remarkably versatile elastomers, C/R Sirvene engineers are producing flexible molded parts for many vital fuel, lubricating, hydraulic and pneumatic systems. One, Viton-A*, can be compounded to produce parts that function dependably at 600° F., and for short periods up to 750° F. The other important feature of Viton compounds is their excellent resistance to corrosive chemicals, chlorinated solvents as well as both synthetic and petroleum base fuels and lubes. At the other extreme, C/R compounded Silastic LS-53** parts are providing low temperature operation down to -80° F. They also exhibit excellent resistance to synthetic and petroleum base fluids up to 350° F., and function well in propane up to 500° F. For temperatures as low as -350° F., C/R recommends Teflon* compounds.

C/R Sirvene engineers have an intimate knowledge of these elastomers. They also have perfected special techniques in processing which still further improve the physical properties of the molded parts. If your problem involves high or low temperatures, close tolerances, and compatibility in advanced design fuel, lubricant or hydraulic systems, get in touch with us at once. We have the skill and the facilities to help you.

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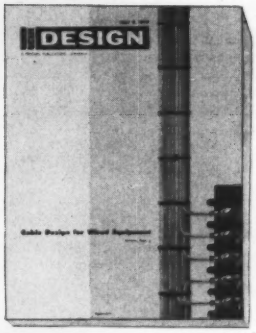

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How to avoid a common cause of machine downtime

Even well designed and engineered machines can turn out to be big headaches. Common cause: Downtime due to excessive maintenance of electric controls.

Electrically operated machinery is only as good as the controls which govern its operation. Minimum electrical maintenance means less machine downtime.

Hint: To insure maximum operating efficiency for *your* machinery, check the above photograph. It shows the contact tips (at right) from a Clark Type "CY" A-C Motor Starter after one year of continuous service with frequently as many as 5,000 operations per hour. Compare them with the new, unused tips at left above.

See for yourself that except for slight discoloration and minute pitting the used contact tips show very little evidence of wear even after one year of steady operation. Many more years of reliable, maintenance-free (and downtime-free) service are assured.

Clark's exclusive "arc quenching" principle, which works through the use of strong, multi-turn magnetic blowouts and double-break contacts, is the answer.

The action of the magnetic field not only forces the arc to rotate, moving it continually over contact surfaces, but tends to "quench" it at the same time. As a result, there's less wear on contact tips and a substantial reduction in maintenance requirements – much less machine downtime.

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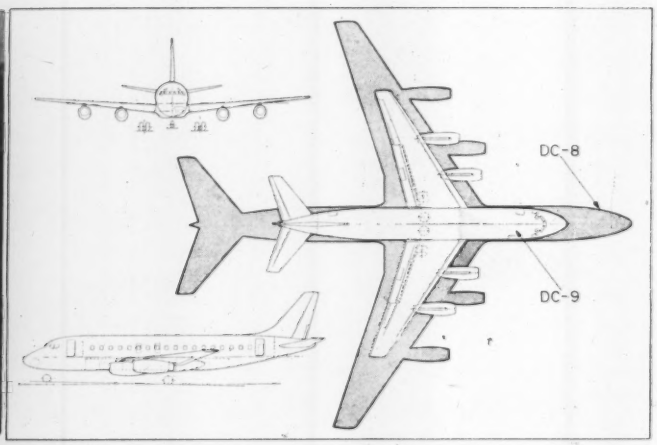
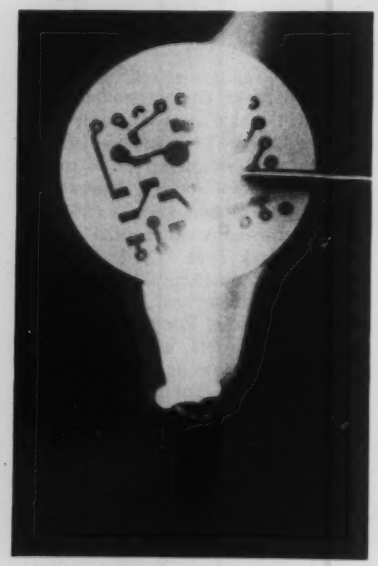


Turbofans Will Power New Jet Airliner

Designed for short-medium haul service, Douglas Aircraft Corp.'s new DC-9 will take advantage of high-power-to-weight, fuel-saving turbofan engines. The swept-wing airliner, resembling the bigger, longer-range DC-8 in appearance, will carry 68-92 passengers for distances up to 2500 mi. Its four Pratt & Whitney JTF10A-1 turbofan engines, each developing a constant 8250 lb thrust at sea level (up to a 90-F day), will give the craft DC-8 speed, but make it competitive in economy and performance with the piston-powered DC-6 on short-haul flights. Comparative data on DC-8 and 9 are shown below.

Size—Performance	DC-9	DC-8
Span (ft)	94	139.7
Length (ft)	103	150.5
Capacity, no. passengers	68-92	116-176
Takeoff weight, max (lb)	119,330	287,500
Range, max (mi)	2590	5830
Speed, average cruise (mph)	528-584	590

Rugged Printed Circuit Won't Melt at 1300 F



Wires Are Fired on Alumina In High-Temp "Molumina" Board

STAMFORD, CONN.—Temperature resistance to 1300 F is inherent in a new printed circuit developed by Advanced Vacuum Products Inc. Substrate or base material on which the wiring is printed is alumina—an oxide of aluminum so hard that only a diamond can cut it. Wiring is a molydenum-manganese compound.

After being fired on the board, the wiring compound is brazed. The resulting bond is so rugged that the circuitry cannot be torn or removed without breaking the ceramic board. According to AVP's production manager, George L. Heitman, the Molumina circuits are still in the development stage.

Low-G Drive Described For Vehicle in Space

Ionic Propulsion Suggests Cable-Car Spacecraft

SEATTLE — Nuclear-ionic propelled spacecraft with radioactive power supply separated from the passenger cabin was suggested by Dr. Gail B. Shook, Lockheed Missiles and Space Div., Sunnyvale, Calif., at the recent AIEE summer meeting. Dr. Shook envisions the passenger compartment connected to the power supply by a mile-long coaxial cable.

The unique approach to an ionic low-thrust engine involves direct conversion of nuclear power to electrical energy. It bypasses one step in the normal thermal-to-mechanical-to-electric conversion. The plan is reportedly "within our technical

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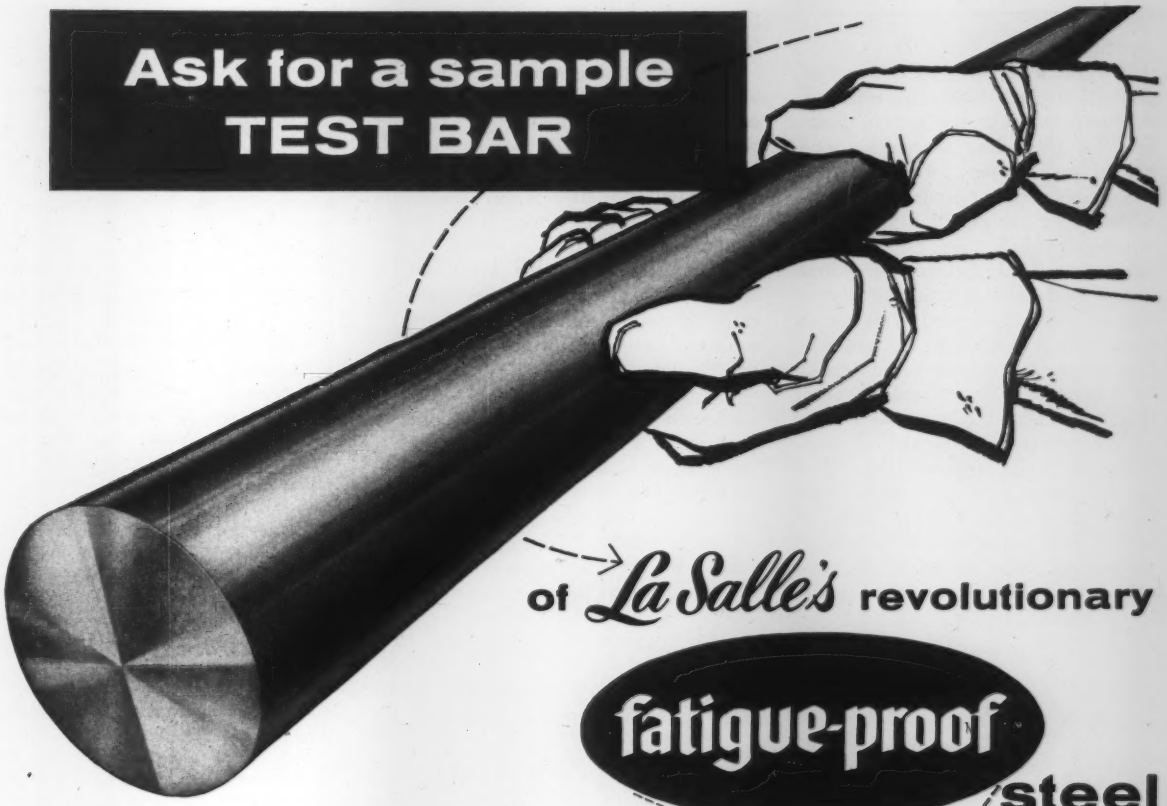

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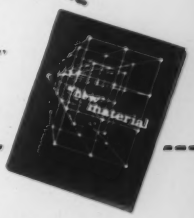

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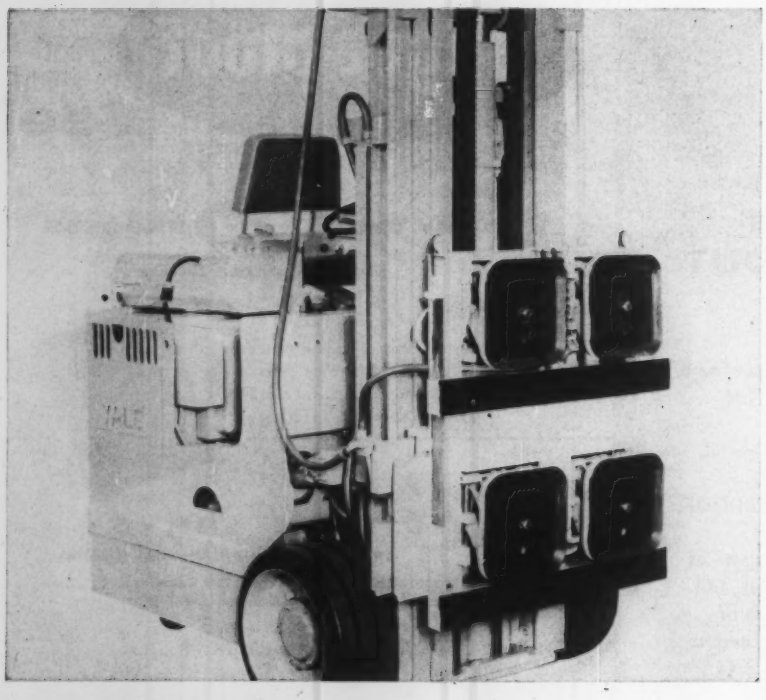
capacity."

Weight and size reductions of propulsion components are reported sufficient to make the system practical for propelling a vehicle once it's in outer space. Also, because the passenger compartment is separated from the power supply, necessary shielding can be reduced. Weight of lead shielding required has so far been the major argument against nuclear power for planes or spacecraft. Since, in the gravity-free environment, the cable would be subjected to only small stresses, there is no reason such a system would not prove practical.

Details of the proposed propulsion system include a 1000-kw power supply to provide a thrust of 0.001 g—all that is needed for "in-space" propulsion. The reactor would contain 200 kg of fully enriched uranium, allowing about one year of full-power operation.

A larger cylinder would serve both as reactor housing and as power converter. A double liner shell would be used. Hair-thin space between walls of the liner would be divided into tiny power-producing cells. Intense heat from the reactor—about 2100 C—would boil electrons off the inner liner and condense them on the cooler outer skin. Electrons condensed in thermionic cells are transformed into voltage.

Electrical energy generated would be transmitted via cable to the ionic propulsion chamber at the rear of the space vehicle. Here cesium, the fuel supplied, would vaporize and ionize from the heat produced in a tungsten matrix. Ionized particles would be accelerated and squirted out a nozzle to provide thrust.



Vacuum-Lifting Lift Truck

Vacuum powered attachment designed for lift trucks simplifies handling of major household appliances and other cartoned goods. Developed by Yale & Towne Mfg. Co., Philadelphia, the vacuum lift holds up to four filled cartons at a time. It eliminates clamps and fork arrangements at the front of the truck, and greatly increases the truck's maneuverability. Each of the four 12 by 12 in. cups has a holding power of approximately 1300 lb. Sensing devices actuate solenoids to transfer vacuum pressure from reservoir to cup as soon as contact is made with the load. The attachment is designed for use only with treated cartons whose porosity has been approved by Yale Material Handling Div.

Topics

Russians are flying model airplanes, not for fun, but to study the lower atmosphere. Meteorgraphs are carried aloft by radio-controlled monoplanes which are of the pusher type to prevent motor heat from affecting readings. Very accurate readings can be made of altitude of low clouds' lower boundaries, because the models can be held directly below and near to clouds. They fly to nearly 20,000 ft.

• • •

Tireless tape recorder plays a two-hour recording then repeats it until the tape magazine is changed or the machine is turned off. The first tape magazine to play continuously by eliminating all threading, rewinding, reversing, or flipping, Fidelipac forms a continuous loop. It is unwound from one spool at the center and rewound automatically on the outside of the same spool. Operation of the player is described as "as simple as mailing a letter," probably because that's the way the machine works: The magazine is slid through a slot to start the music and slid out again when it has played. Fidelivox is the name of the player; both magazine and player are made by Fidelivox-Fidelipac Div., Waters Conley Co. Inc. of Delaware, Skokie, Ill.

• • •

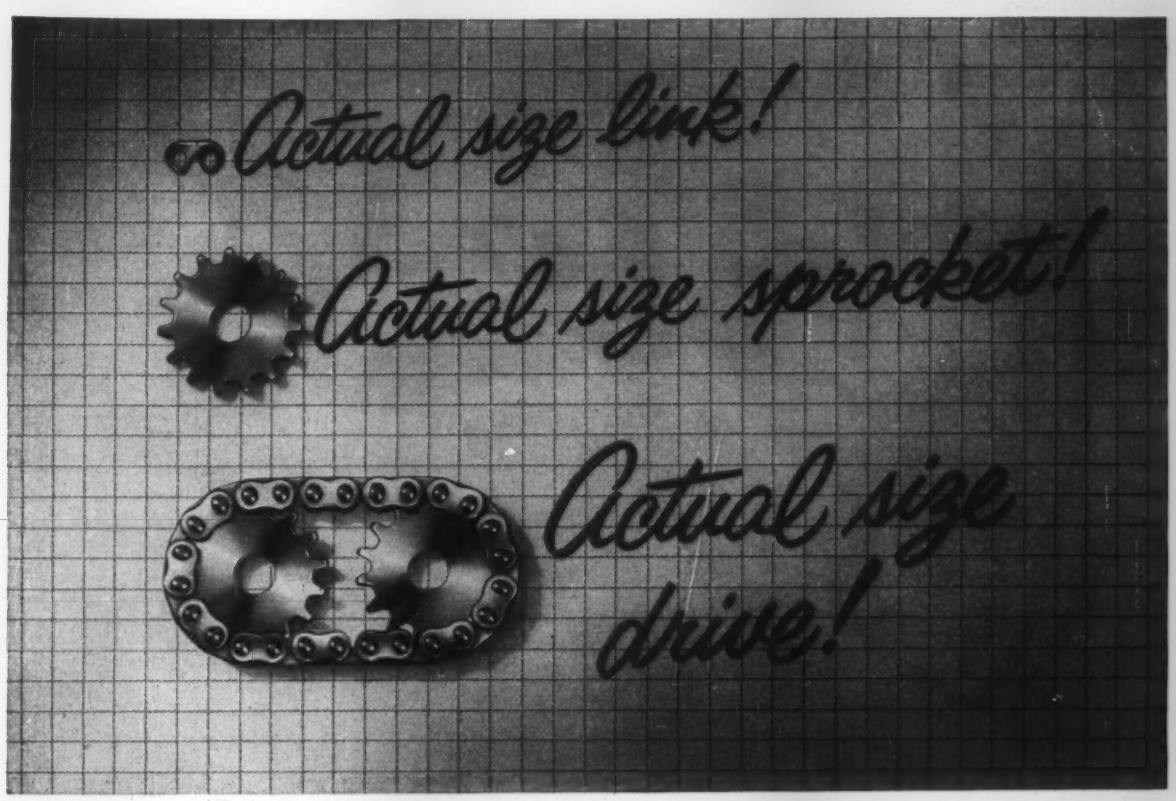
Bingo is mechanized by means of a marker-dropping device patented recently. The plastic dispenser has a hopper to hold markers and a chute with a mechanical finger at the end. The player holds the chute over a card, quickly and easily releasing chips where they are wanted. The little gadget enables a real bingo-ite to play numerous cards simultaneously without danger of spilling a handful of markers.

• • •

Fission and French horns are joined in contemporary music. "Overture for a Nuclear Reactor" will be presented for the first time this year by the Oak Ridge Symphony Orchestra.

• • •

The light barrier will never be broken; therefore, man will never be able to reach other solar systems, according to two leading space scientists. Dr. James A. van Allen of the State University of Iowa and Dr. Homer E. Newell Jr., assistant director of NASA, concur in the theory that radiation would deteriorate exposed surfaces of a space rocket. At only one-third the speed of light, each square centimeter of a space craft would be bombarded by 9 billion protons and 9 billion electrons per second.



. . . and actually over 98% efficient

LINK-BELT 3/16" PITCH SILENT CHAIN

Complete drives as small as two inches! Weight as little as .07 pounds per foot! Efficiency better than 98%! Link-Belt 3/16-in. pitch silent chain is the perfect combination of compactness and split-second precision.

At high or low speeds, this chain is quiet, positive, smooth. In fact, with its unique link design, it's the smoothest-running chain in use today. In many limited-space applications, it has replaced expensive, precision-cut gear trains. And its versatility makes it ideal for a wide assortment of equipment—ranging in diversity from cigar-making machines to guided missile controls.

Available in carbon and stainless steels . . . for ratios up to 12:1, speeds over 7500 rpm. For full details, contact your nearest Link-Belt office. Ask for Book 2510.

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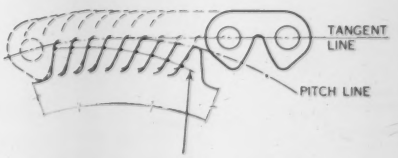

Exclusive link form of Link-Belt 3/16-in. pitch silent chain permits chain to enter the sprocket wheel on a line tangent to its pitch circle, thus eliminating the undesirable effects of chordal disturbance.

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Welded Tube Approved In New JIC Standard

CLEVELAND—New JIC standards for hydraulic-line tubing now include high-quality welded-steel tubing. Standard for welded-steel tubing, found in appendixes to revised standards for hydraulic tubing, covers chemical composition of steel, mechanical properties, dimensions, quality, and packing.

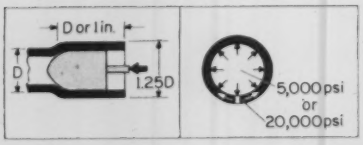
Chemical Composition

Element	Content (per cent by wt.)
Carbon	0.18 max
Manganese	0.30-0.60
Phosphorus	0.050 max
Sulfur	0.055 max

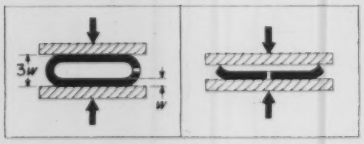
Dimensional Tolerance

Nominal OD (in.)	OD (in.)	ID (in.)
3/8	±0.002	±0.005
3/8 to 5/8	±0.0025	±0.0025
5/8 to 2	±0.003	±0.003
2 to 2 1/2	±0.004	±0.004

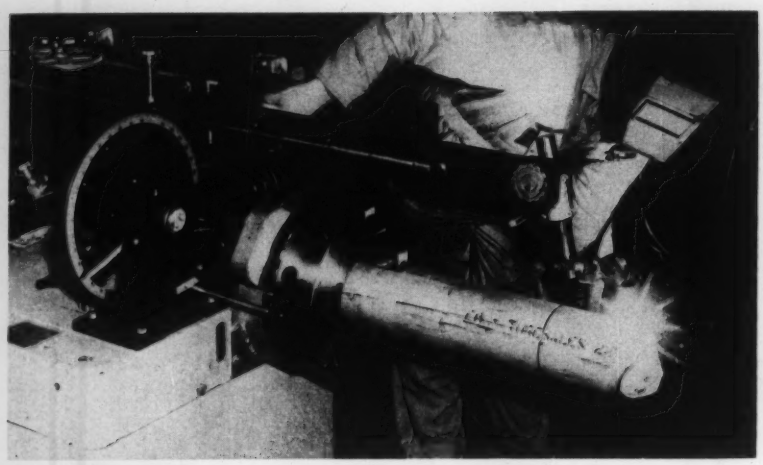
Wall thickness shall not vary more than ± 10 per cent.



Expansion and pressure tests will check ability of tubes to withstand internal stresses. Ductility is measured by expansion test (left). OD of tube must enlarge 25 per cent without breaking or splitting. Tube must withstand 20,000 psi internal pressure or 5000 psi hoop stress (right), whichever occurs first.



Flattening tests will prove out ability of seam to withstand flexure stresses in either direction. Three-inch sections are cut from every 1500 ft. One of these is mashed flat to a height of three wall thicknesses, (left). The weld, located 90 deg from the direction of force, must not show cracks or splits. Another section is opened and flattened from the inside (right). Weld must show no cracks, lack of penetration, or overlap.



Drafting Machine Cuts Pipe

Complex contours which result when different sized pipe intersect at odd angles are machine cut precisely and easily at the Hanford atomic plant. It's done with General Electric's combination of two commercially available products: A Heliarc cutting torch, product of Linde Air Products Co., Seattle, Wash., and a Mechanical Draftsman, product of Steffan Mfg. Corp., Salem, Ohio. Four dials control all features of the most complicated cut. One dial is set to the inside diameter of one pipe, another to the outside diameter of the mating pipe; a third dial controls angle of intersection, and the fourth the offset of centerlines. The machine takes it from there, producing a clean, beveled cut without hand-processing.

Checker's Taxi Groomed for New Market

Roominess and economy are design keynotes of Checker's new Superba. The oft-postponed passenger-car version of Kalamazoo's reliable taxi is presently being offered in a six-passenger, four-door sedan, with a station wagon scheduled for production later this summer. Mounted on a 120 in. wheelbase, 1 to 2 in. longer than the "low-price three," Superba is just 200 in. long, or 8 to 11 in. shorter than Ford, Chevy, or Plymouth. And contrary to the low-silhouette trend, the car is 61 in. high (56 in. is about average). Checker engineers have used the height to give passengers plenty of head room, and to eliminate the drive-shaft tunnel in the rear passenger compartment. There is even room enough in the rear to mount two foldaway seats. As an economy feature, Superba's fenders are two-piece construction, easily detachable for repair or replacement. Other subassemblies are said to be similarly inexpensive to service. The car is available with two six-cyl Continental engines—a 95-hp L-head or an optional 125-hp OHV. Automatic transmission and all power assists are optional. Suggested price: $2541 f.o.b. Checker Motors Corp., Kalamazoo, Mich.

Photograph courtesy Ohio Seamless Tube Division of Copperweld Steel Company

Aristoloy uniform quality steel bars pay off on hot piercing operations

Few manufacturing operations match piercing of tube rounds as a severe test of quality. Rapid displacement of metal and immediate increase in temperature reveal internal defects... magnify the slightest surface imperfections.

Copperweld's precise melting produces a prime ingot of uniform chemistry. Careful conditioning and rolling deliver bars that meet Aristoloy piercing quality specifications. Available in a full range of A.I.S.I. standard analyses.

For complete information about Aristoloy blooms, slabs, billets and bars, in carbon, alloy, stainless and leaded, call Copperweld in your nearest large city, or write for NEW PRODUCTS & FACILITIES CATALOG.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

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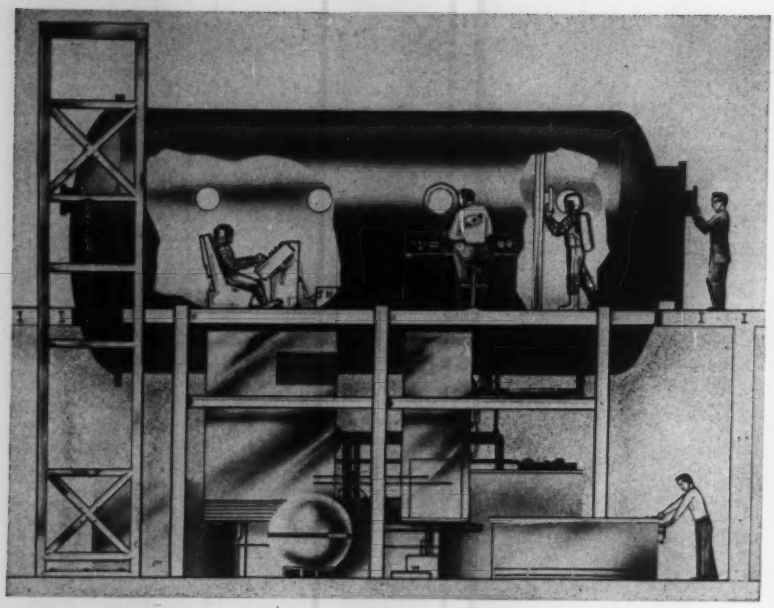
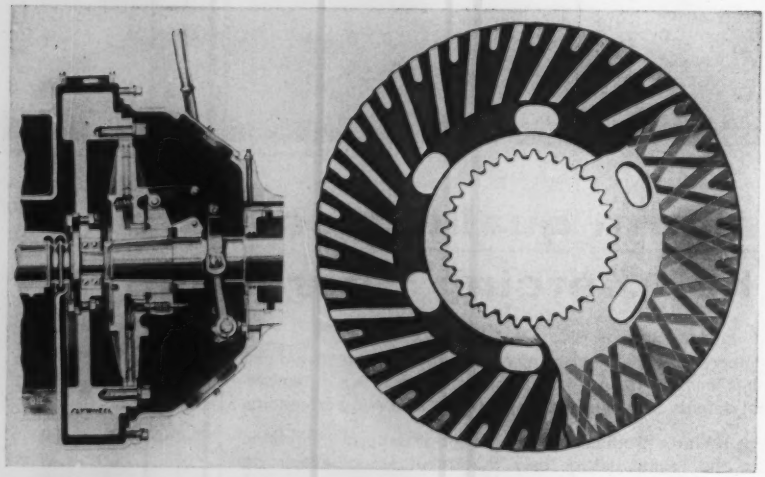


Space Chamber To Simulate 150 Miles Up

First space-environment chamber capable of taking a human to a simulated altitude 150 miles above the earth will be completed in early 1960. As part of Republic Aviation Corp.'s development program, the chamber will be used to test space suits and to investigate physiological and psychological reactions of man. It will also aid in developing materials and components for space vehicles. The chamber will be 14 ft diam by 30 ft long. Specially designed pumps will produce the ultra-low pressures found in outer space. At present, the most advanced chamber in existence is capable of simulating an altitude of only 85 miles.



Ventilated Centerplate Cools High-Speed Clutch

Cooling-air ducts are provided between ribs on mating faces of a split centerplate in the clutch of this power takeoff. Twin Disc Clutch Co., Racine, Wis., says the added cooling dissipates starting-load heat which often damages conventional centerplates. Tapered roller bearing in the power takeoff uses oil rather than grease for safe operating temperatures at high speeds. Bearing oil is provided by a slinger dipping into the sump. In normal operation (ten engagements or less per day) the unit needs lubrication only twice a year.

Urethane Torsion Coupling Slims Auto Driveshafts

High-Strength Plastic Outlives Coupling's Metal Parts

DAYTON, OHIO—A rubber-like synthetic may be responsible for more room and smoother riding in 1960 cars.

A thin layer of cast urethane between two metal sleeves creates a driveshaft torsion-elastic spring that will transmit full engine torque and yet dampen vibration and cushion shock. The tremendous adhesive qualities of the urethane material, known as Daycollan, make possible a much smaller driveshaft coupling. This could lead to smaller humps in cars of the future.

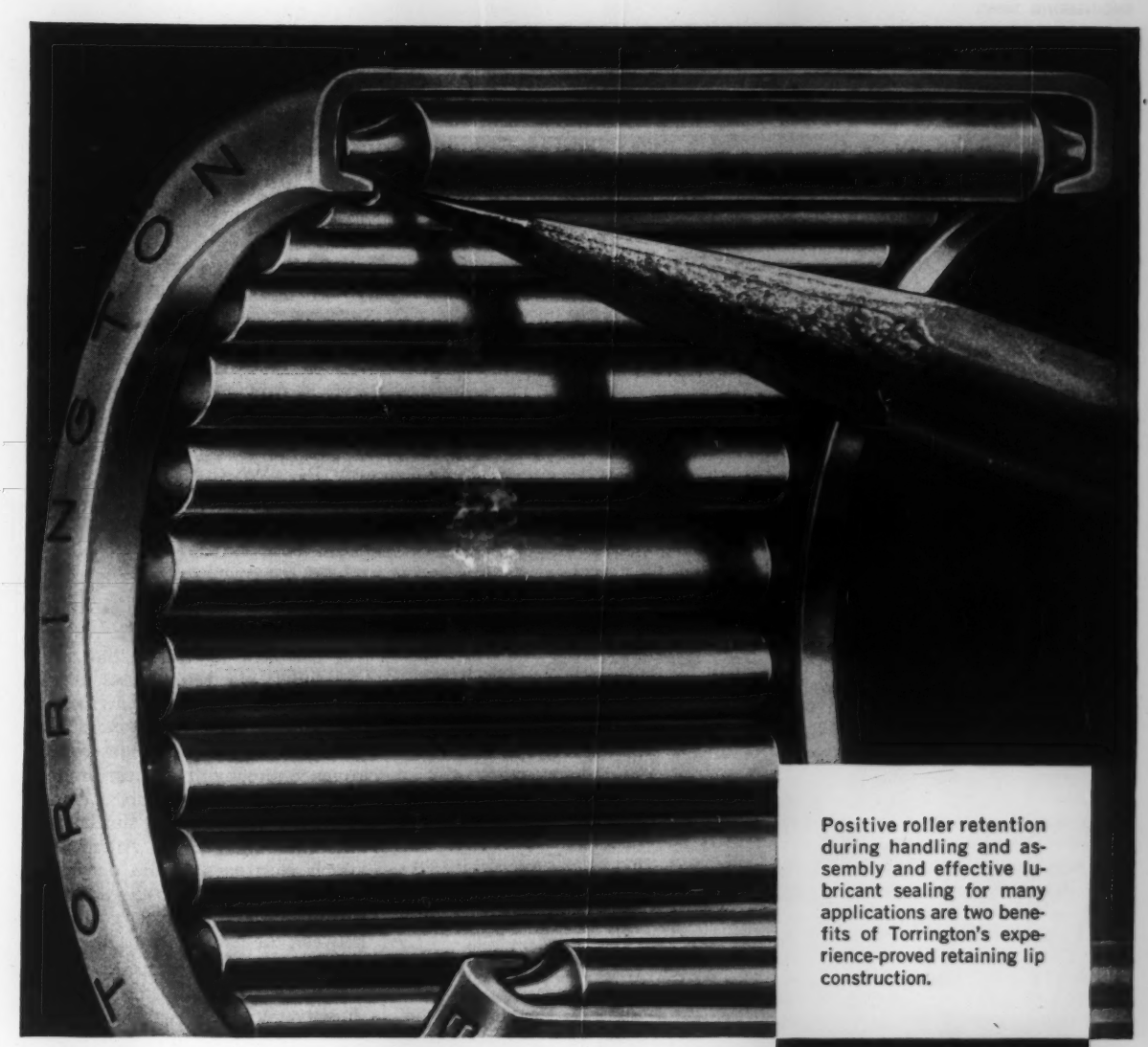
Daycollan forms a bond with any surface. Both its strength and abrasion resistance are termed amazing by Dayton Rubber Co., one of the largest suppliers of urethanes. In torque tests, metal breaks down before the synthetic material shears. To approach such performance with prestressed rubber, four or five times the thickness of material is required.

Another form of urethane is a plastic foam. Foam-filled tires do not go flat even after being fired upon from point blank range by experimenters armed with rifles and revolvers. Tire design engineers are collaborating in experiments, as are foam experts.

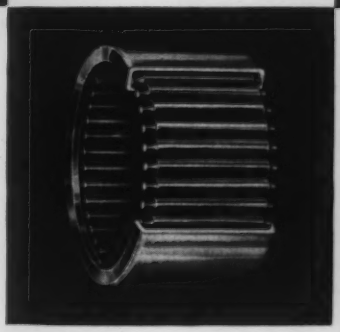
Flame-Proof Plastic Can Now Be Synthesized

MENLO PARK, CALIF.—Plastics that won't burn may soon be available. Although chemical makeup of a flame-proof plastic has long been known—it requires saturating the monomers with chlorine atoms and keeping the resulting monomer stable—the synthesis has, up to now, not been practical.

Stanford Research Institute reports development of a successful synthesis technique. The chlorine saturated monomer has been polymerized into a plastic material that will not support combustion—trichloropropene. The monomer may co-polymerize with many other synthetic materials. Potential uses for the new materials are legion.



Positive roller retention during handling and assembly and effective lubricant sealing for many applications are two benefits of Torrington's experience-proved retaining lip construction.



This little lip makes a big difference!

The turned-in lip at each end of Torrington Needle Bearings positively retains the trunnion - end rollers and makes the bearing truly a complete unit, with no possibility of roller fall-out.

This unit construction simplifies installation and servicing. The closely controlled clearance and the large area between cup lips and shaft form an effective labyrinth seal. Also this retaining lip allows pregreasing the bearing with the proper lubricant for each application.

Long experience with the Torrington Needle Bearing in thousands of applications has proved the merit of this and other features in efficient performance and long service life. Make sure *your* product benefits from the best that experience has to offer—specify Torrington Needle Bearings. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE ROLLERS • BALL • THRUST

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Victims of heart disorder have a better chance for recovery since designers have teamed with medics to develop a new transistorized heart control. For permanent control, patients can even be . . .

Wired for Life

A POCKET SIZE electronic instrument that can substitute for nervous control of the heart has been developed by Atronic Products, Inc., Bala-Cynwyd, Pa. With it, malfunctioning hearts can be stimulated to near normal activity. Rate and strength of pulse can be controlled to avoid exceeding the capabilities of a weak heart.

Current source in the Atronic Pacer gives a measurable and reproducible impulse to the heart regardless of changing impedance that accompanies changes in physical state of the patient. Dial was installed because physicians trained with electrocardiographs could interpret swings of the needle more readily than the flashing lights previously used.

Small electric currents cause a muscle to contract just like nerve impulses, which are themselves electric currents. Machines that time and deliver electric impulses to trigger heart action, called *pacemakers*, usually require an open incision of the chest so that electrodes can be attached directly to the heart muscle. Needless to say, such an operation is quite a physiological shock to an already-ailing patient. Attempts to attach electrodes to the outside of the chest, although somewhat successful, introduce too many variables between the heart and the electrode.

The Atronic pacemaker has a unique electrode built to be inserted directly into the heart muscle without major surgery. In prototype models, a hollow needle with a telescoping sleeve penetrates the chest wall; the sleeve extends until the end containing the electrode contacts the heart. Then the sharp tip of the electrode, with a specially built stop to control depth of insertion, is pressed into the heart muscle.

Production models are even simpler. Wire is threaded through a typical hollow hypodermic needle and folded over at the end to form a type of barb. Guided by signals from the heart, the surgeon inserts the hypodermic needle containing the folded-over wire into the heart muscle at the proper spot. The needle is withdrawn, leaving the flexible wire to follow beating motions of the heart.

An active heart is continually sending signals from its natural

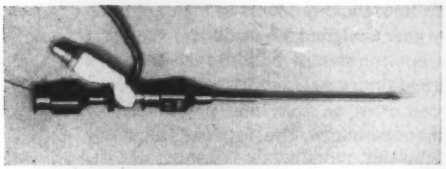
Production version of electrode is inserted (left) with the aid of a standard hypodermic needle. Shank of needle and wire are insulated with 0.002-in. Teflon coating. Anode attached directly to patient's chest is a standard surgical needle. Needle is withdrawn (right) after successful attachment.

pacemakers, and these can be received through the electrode and read on a dial to steer the surgeon to a very precise location of the electrode in relation to the heart.

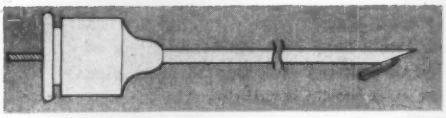
For hearts too sick to send a readable signal, the pacemaker is equipped to start sending a weak version of its pulsed signal. By reading impedance to this signal, the surgeon can judge when the electrode has made proper contact.

The transistorized, battery-operated model is small enough for a doctor to carry in his bag, or for an ambulatory patient to wear comfortably on a belt or in a pocket. Batteries can be tested or changed without interrupting the pacemaker function. When not being used actively, the pacemaker may be used to monitor the function of a weak heart.

The pacemaker is used to revive or stimulate heart action after injury or shock; it may be used after heart massage or other emergency treatment for long-term stimulation; it can be connected as a monitor or stimulator for several days after cardiac arrest or surgery to carry the patient over the first critical 24 to 36 hrs; it is also used to counteract heart blocks from heart surgery or disease.



Hollow needle and sleeve guide the flexible electrode of prototype pacer through the chest wall and cavity. Later the sleeve can be retracted, leaving electrode free to follow the motion of the heart. Electrode wire is insulated with especially developed, inert epoxy coating.



Heart signals guide electrode placement in this simple system. Wire folded over tip of the needle forms a barb-like protrusion which effectively prevents accidental disconnection of electrode. Stranded wire used in this version is more flexible than single-strand wire of prototype electrode; it follows heart movements with less strain on the anchoring point.

Hub assembly with integral preloaded duplex ball bearing, used in electronic missile system developed by Westinghouse Air Arm.

"IN-BORN" BEARING IN HUB ASSEMBLY

Gives Better Accuracy, Weight and Cost

Important advantages can often be gained by "designing in" bearings as a part of the unit in which they operate. A case in point is this hub assembly, produced and bearing-engineered by ITI.

Here, the two outer raceways and one inner raceway are formed in the hub and shaft; and the second inner ring — made separate to permit assembly — is close to a zero-tolerance fit. Compared to the usual design (using separate bearings), this construction gives (1) higher and more uniform accuracy, through elimination of 6 radial tolerances; (2) less weight and greater compactness, by eliminating 3 rings; and (3) lower total cost.

Other features include low running torque, labyrinth seals, high vibration resistance, and a dished hub held within .001" of the mathematically-specified contour.

In comparable ways, you too can benefit through our ability to design and produce bearings having unusual compactness or configuration, heat resistance, corrosion resistance, ultra precision, or other special properties. Let's talk it over.

FREE BULLETIN AFB-2 tells about the factors involved in special bearing applications, describes our work in this field, and shows a wide variety of special bearings. Write for it!

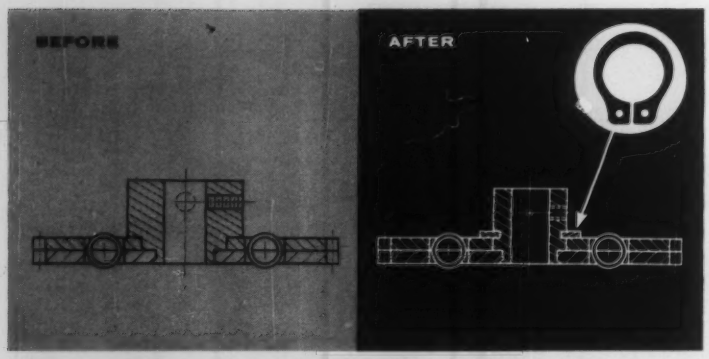
INDUSTRIAL TECTONICS, Inc.

ITI

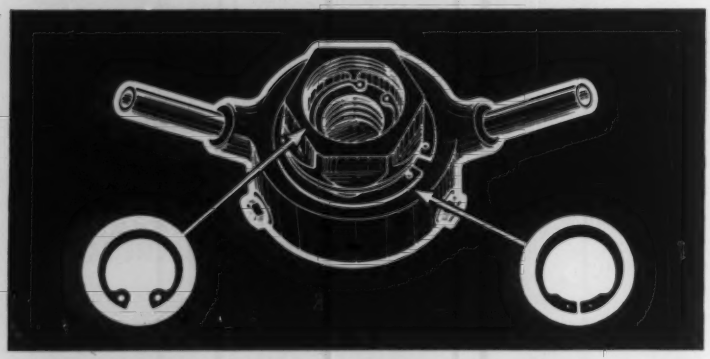
MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3682 JACKSON RD., ANN ARBOR, MICH.

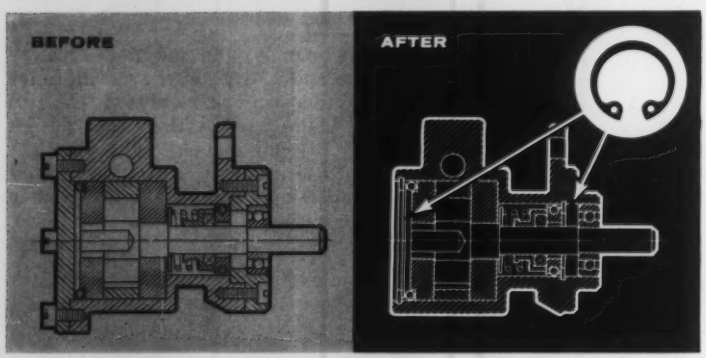
WESTERN DIVISION PLANT: COMPTON, CALIFORNIA



Gear assembly improved. A Waldes Truarc Series 5100 retaining ring in this anti-backlash gear assembly eliminates machining and staking operations, reduces hub size, and allows easy disassembly, after gears are cut as a unit, for faster, better deburring. **Typical savings: $350.00 per 1000 units.**



Threaded retainers eliminated. In this self-sealing coupling, costly internal and external threaded retainers were eliminated by easy-to-apply internal (Series 5000) and external (Series 5108) Truarc retaining rings. **Savings per unit amounted to $4.02.**



End-cover design simplified. In this general-purpose pump, two Waldes Truarc, Series 5000, internal retaining rings make possible the elimination of two cover-plate castings (plus machining) and eight screws (plus drilling and tapping). Weight and dimensions are reduced and assembly and disassembly are greatly facilitated. **Typical cost savings: $1.48 per unit.**

©1959 WALDES KOHINOOR, INC.

Designing for axial assembly with Truarc retaining rings

eliminates parts, machining, speeds assembly, simplifies maintenance

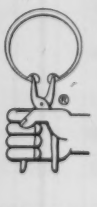
The proper application of retaining rings on or in axial assemblies can often effect startling simplifications and economies in design when compared to corresponding designs with conventional fastening devices. A few typical examples, using basic types of retaining rings, are shown in the accompanying drawings.

Threading, tapping, drilling, facing and other costly, time-consuming operations can be eliminated. Retaining rings are already in wide use in a tremendous variety of equipment ranging from household products to high-precision military gear designed for use under the most severe environmental conditions. They are quickly and simply installed in easily cut grooves which can often be machined simultaneously with other operations. The rings can frequently replace bulkier, more costly fastening devices —such as nuts, screws, studs, threaded sleeves and retainers, cotter pins, set collars, rivets and machined shoulders.

What's more, rings frequently make practical designs which could be achieved with no other known fastening device.

Although the ring types shown here are basic, Truarc retaining rings come in 50 functionally different types, as many as 97 different sizes within a type, 6 metal specifications and 13 finishes. You'll find detailed descriptions of Truarc retaining rings and assembly tools, plus more than 70 typical applications in the new 24-page catalogue RR10-58. Write for your copy today.

And remember, Waldes engineers are always ready to help you solve your application problems—whether it involves one of the standard Truarc rings or a "special" to fit your particular requirements. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y. 9.1



WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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JULY 9, 1959

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414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
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422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
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428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
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430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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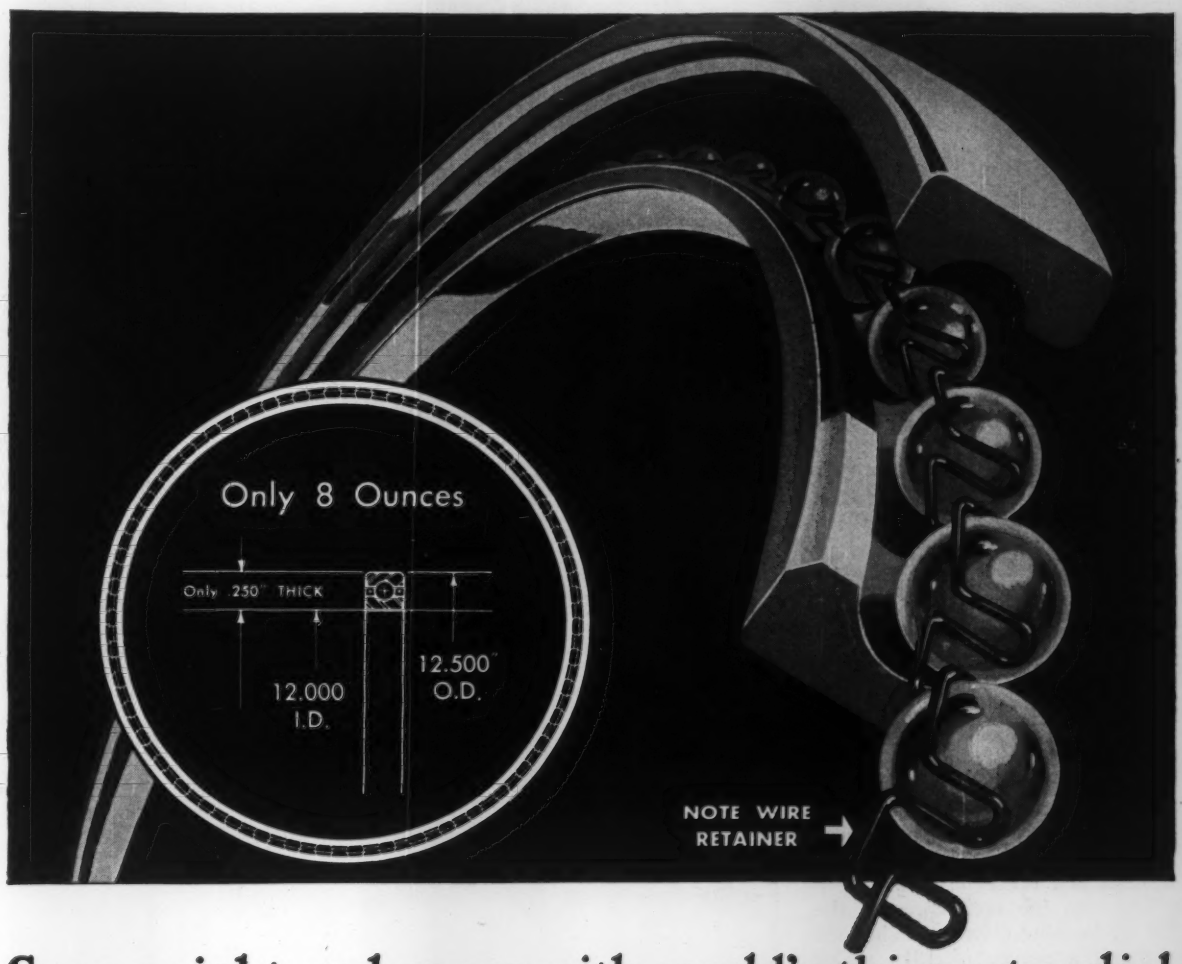


Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

. . . now carried in stock in 4" to 12" bores

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

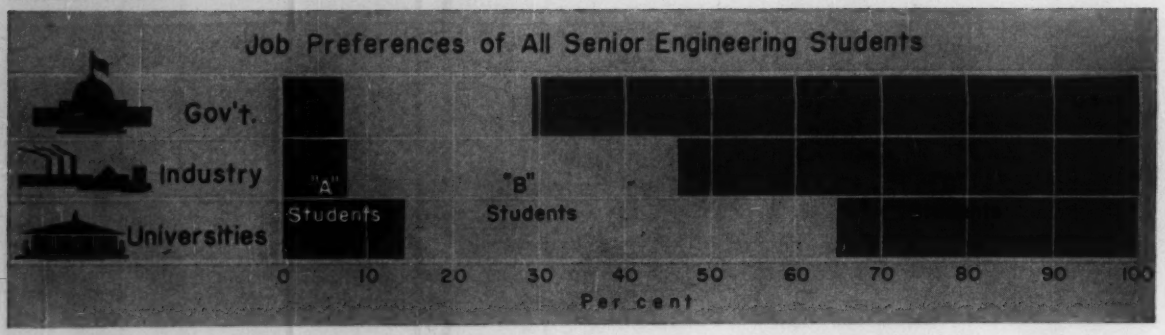
THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561R

All types of ball and roller bearings — 4" bore to 178" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings

Circle 413 on Page 19



Top Grads Duck Government Jobs

JOSEPH L. SEMINARA
Human Factors Specialist
Dover, N. J.

GOVERNMENT recruiting is at a disadvantage. While enough graduating engineering students seem to be interested in governmental employment to satisfy quantity (and budgetary) needs, grades earned by students preferring to work for Uncle Sam are lower than those earned by students preferring industrial and academic jobs.

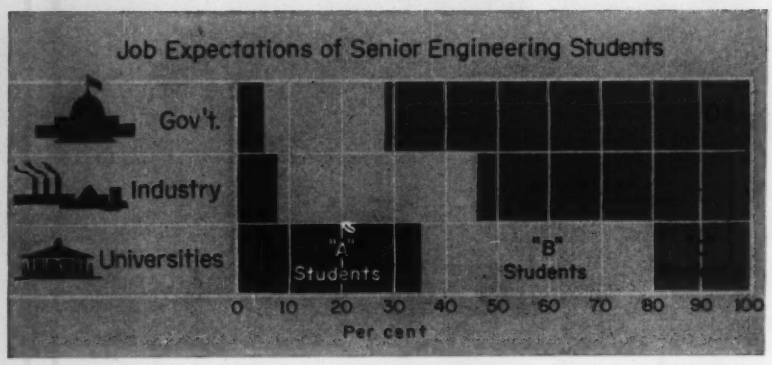
Data on job preferences of the '59 engineering class were obtained through a survey of 1016 senior students from schools throughout the country. Of the students preferring government employment, only 29 per cent had maintained **A** or **B** averages. Averages of the group wanting the academic life were much higher—65 per cent held **A** or **B** grades. The industry-bound seniors boasted 46 per cent **B** or better averages.

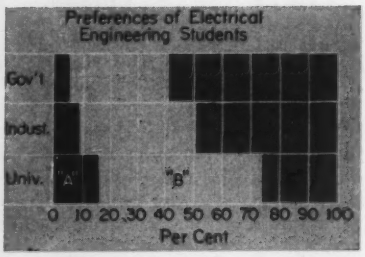
The largest subgroup surveyed was 388 electrical engineering majors. Here, 42 per cent with government-employment aims were **A** or **B** grade people. Relative standing was the same however, for 74 per cent of the academic people and 51 per cent of the industry people earned **A** or **B** averages.

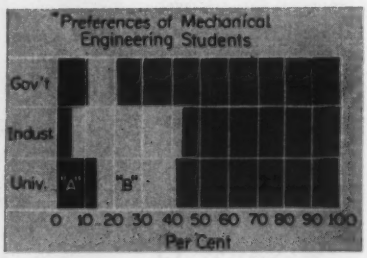
The second largest subgroup was made up of 286 mechanical engineering majors. Here, results were again essentially the same.

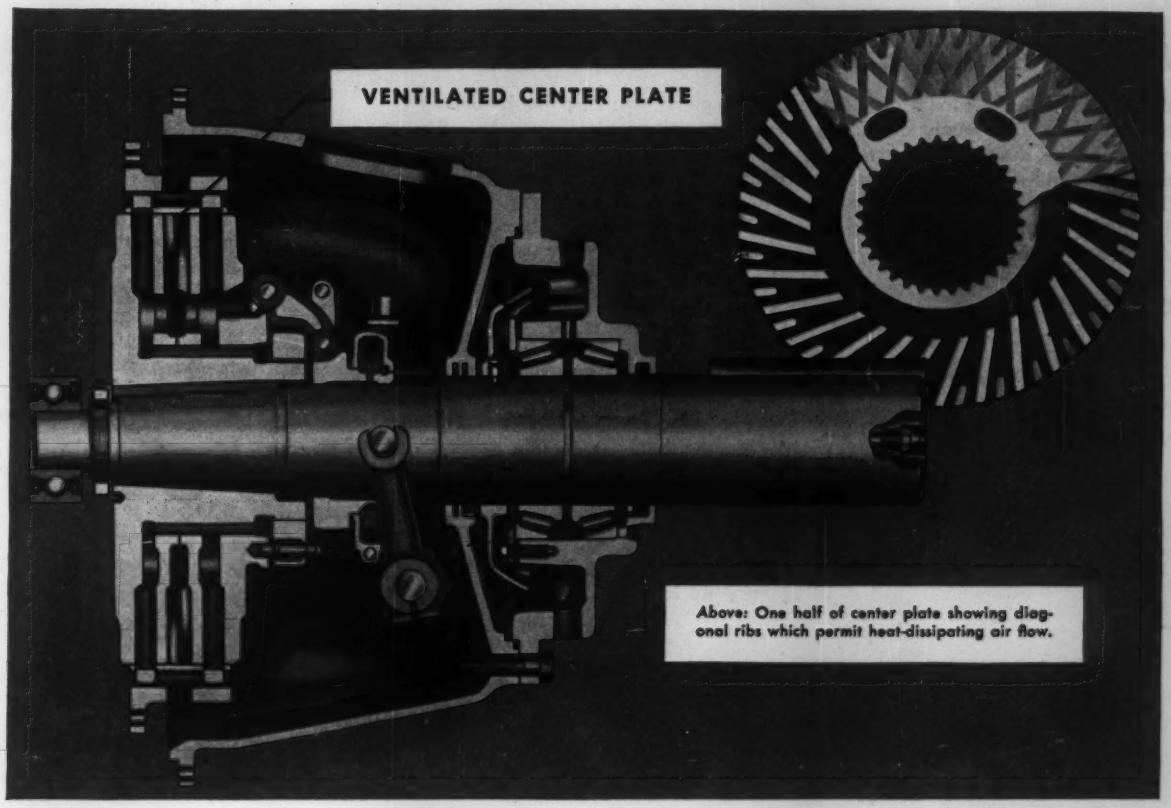
Students preferring a job area did not necessarily expect to find work in that area. The majority of **C** students preferring the academic career expected to find government or industry jobs, possibly because they felt they could not obtain campus jobs. The number expecting government employment was considerably higher than the number preferring it. However, about the same percentage from the upper grade categories was maintained.

The survey has serious implications. If the situation continues, efficiency of governmental agencies may suffer. Responsible administrators must determine what known disadvantages of government service can be corrected. Study is required to determine the basis for the negative attitude towards government employment exhibited by higher grade graduating engineers.









High-energy, high-speed power take-off

features ventilated center plate and oil-lubricated tapered roller bearing

Here is a new PTO—Twin Disc Model IBF-214P—designed for high-speed engines not yet off the drawing board . . . *engines developing 300 to 500 hp at speeds up to 3380 rpm!*

These high speeds are possible because of improved design including the elimination of heavy counterweights, thereby improving overall balance and reducing link and pin stresses.

In addition to its high speed rating, this new unit offers two other important advantages over standard PTO's:

1) The ability to withstand high-energy loads through use of a unique center plate design.

High-energy heat loads create uneven thermal stresses which in turn cause clutch failure by starting cracks in the center plate. This problem is usually traceable to heavy starting loads such as occur in rock crushers, heavily-loaded conveyors and similar equipment.

The center plate on the Model IBF-214P Power Take-Off is ventilated by means of a two-piece design with diagonal ribs cast into each plate. Placed back to back, the ribs cross each other to form only small diamond-shaped contact areas, thus allowing air flow to dissipate excess heat.

2) The ability to operate for six months between lubrication periods thanks to improved throw-out collar design and oil lubrication of the tapered roller bearing.

Oil rather than grease is used for bearing lubrication so as to assure safe operating temperatures at the high speeds for which this unit is designed. The top of the bearing carrier has a small cast cavity which is kept full of oil by a slinger dipping into the sump. A drilled hole from this cavity feeds the bearing to assure constant oil circulation.

A special clutch engagement mechanism cuts throw-out collar wear. Lubrication is needed only twice a year in normal service.

Complete details and specifications on Model IBF-214P are available from our Racine office. Request Bulletin No. 308-B, Supplement A.

TWIN DISC

TWIN DISC

Friction Clutches and

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division) Rockford, Illinois

Circle 414 on Page 19

Maneuverable Lift Trucks Fit Small Places

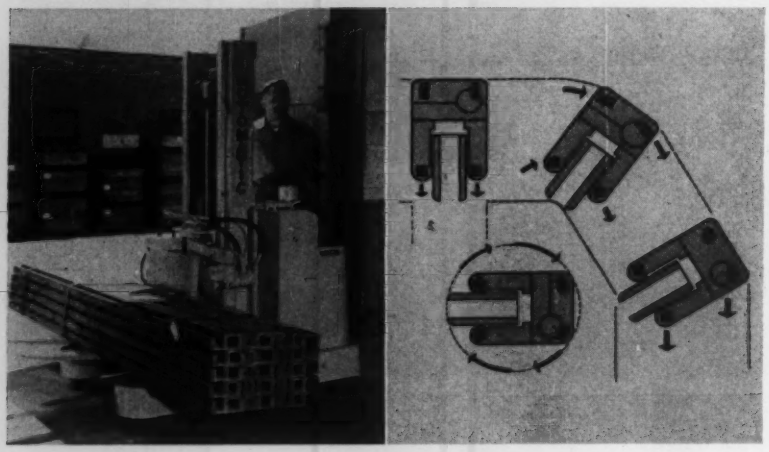
FLOOR SPACE, a rare commodity in every plant, can now be artificially created, thanks to newly developed, highly maneuverable lift trucks. Because they're designed to turn sharper corners, the trucks make narrower aisles possible and permit reduction in floor area assigned to storage jobs. Two of the new breed, demonstrated for the first time at the Material Handling Institute's recent Cleveland Exposition, are manufactured by Automatic Transportation Co., Chicago, and Towmotor Corp., Cleveland.

Crab Truck

Automatic's electric lift truck can travel in any direction, at any angle, regardless of the shape of the load. Stero-Matic steering provides one-lever control of twin drive motors for normal forward or reverse rotation of the drive wheels. When one drive motor is set in forward and the other in reverse, the truck turns without use of the steering wheel. Steering-wheel action controls positions of the wheels and provides angle and side steering.

Because it is able to move in any direction, the truck can work in confined areas, and can make better use of storage space than can conventional lift trucks. It is reported much easier to steer around corners, in tight aisles, and in right-angle stack.

Besides increased maneuverability, the vehicle is equipped with a fork that can reach over an obstacle to pick up a load. The fork swings 30 deg to either side of center. Swing and reach features are controlled with one lever. A tilt device cradles the load to overcome deflection in the attachment.



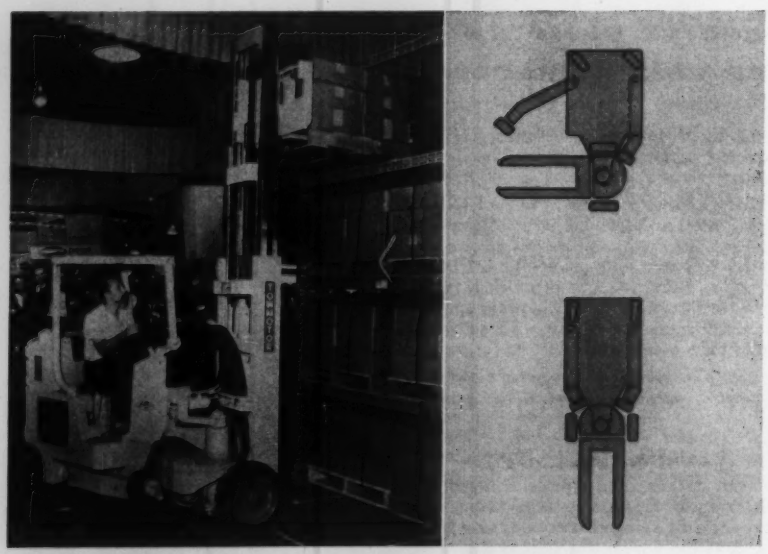
Automatic's truck, 65-in. in over-all length, can turn completely around in a 70-in. circle. Other abilities include traveling at angles and sideways. Truck's 42-in. width permits penetration into narrow aisles to pick up or deposit loads.

Narrow-Aisle Truck

Towmotor's gasoline/LP-gas lift truck obtains maneuverability in another manner: The front end can be rotated through a right-angle for sharp turns and for stacking. The truck is reported to operate in aisles 4 to 6 ft narrower than those required by conventional lift trucks, increasing storage capacity of a given area by as much as 50 per cent.

In normal operation, the Towmotor truck behaves as any ordinary lift truck: Rear wheels are steering wheels and front wheels are driving wheels. For right-angle turns and stacking, however, the normally locked front end can be rotated by running one drive wheel in "forward" and the other in "reverse." Simultaneously and automatically, steering wheels rotate to aid the turn, and an outrigger wheel extends from the side of the truck in the direction of the turn to keep it from tipping.

Heart of the vehicle is the newly developed Towmostatic Drive which is now available on several Towmotor trucks. In this new drive, individual piston-type hydraulic motors mounted on each drive wheel provide motive power. Conventional components such as transmissions, drive lines, and differentials are eliminated. Without the new drive, the front (drive wheel) end of the truck could not be rotated.



Towmotor's truck is a normal lift truck when the front end is locked in position. With the front end rotating, steering wheels turn to "sharp turn" position and the outrigger extends to keep the truck from tipping. Although not currently in production, the vehicle is expected to be marketed in the near future.

Palm Operated, Detented or Spring Return.
Lever Operated, Detented or Spring Return.
Ball Actuated Spring Return.
Pilot Operated Spring Return.
Double Pilot Operated.
Pilot Operated Bucking Cylinder Return.
Single Solenoid Spring Return.
Double Solenoid Momentary Contact.
Six Single Solenoid Valves Manifolded into a Compact Unit Using Standard Brackets and Tie Rods.

HUNT Slim Line CONTROL VALVES

Now available with 8 types of operators. 3-way and 4-way actions. Easily manifolded into compact control centers.

● You'll like these new valves. Only 1″ thick by 3″ wide, they are exceedingly compact and light in weight; can be mounted easily on machines even when space is extremely limited.

Ideally suited for controlling small cylinders, to operate pilots and similar services. ⅛″ or ¼″ pipe tapped. Pressures to 125 p.s.i. Air, water, oil or vacuum service. Stock delivery.

Solenoid valves have the following features as standard; manual over-ride; ½″ NPT conduit connections; valve inoperative with solenoid cover removed.

The side of each valve is counter-bored, trepanned for an "O" ring, and provided with four through holes permitting up to eight valves to be manifolded together and operated from a single supply. Better get full details — now!

More startling HUNT designs to come!

40 Years

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Quick-As-Wink® AIR AND HYDRAULIC CONTROL Valves

Send for the "SLIM LINE" Bulletin No. 581 TODAY!

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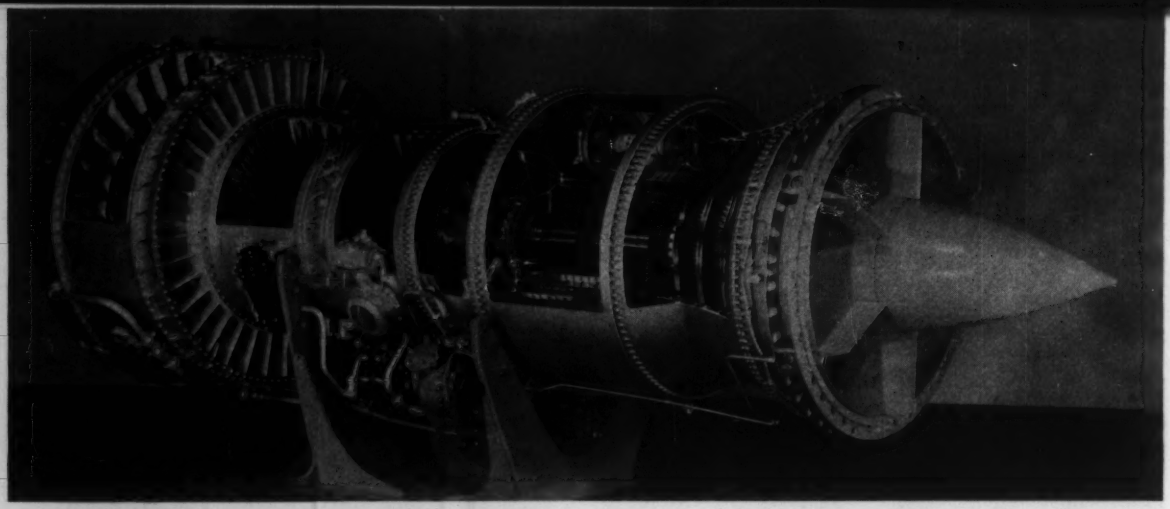


Twin spool engine is a "natural" for turbofan conversion. Fan is integral with first two stages of the low-speed compressor. Starting loads are unchanged since high compressor only is spun in starting. Mounting-pad locations need not be changed since weight of fan added in front is balanced by additional turbine stage.

Quick Conversion—
Turbojet to Turbofan

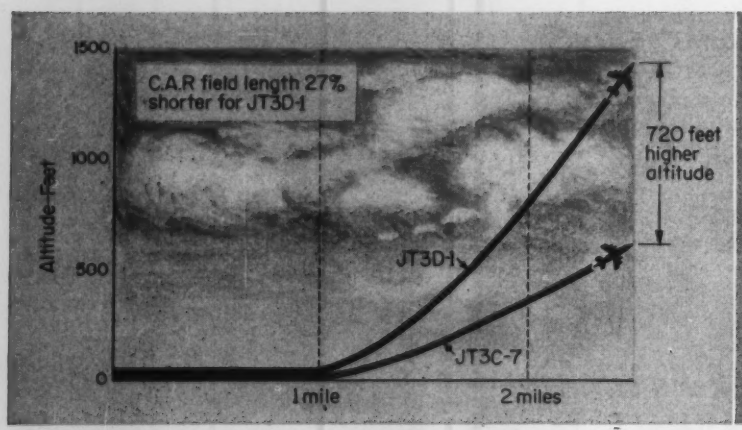
ONLY ONE YEAR engineering lead time produced Pratt and Whitney Aircraft's new JT3-D1, a turbofan version of the twin-spool J57. Seasoned development projects furnished information and hardware for the new components: Fan blades were over-sized compressor blades from the J91 nuclear turbojet; turbine buckets came from a T57 turboprop project.

Basic patern of airflow through the engine was undisturbed, so no drastic changes had to be made in the heart of the engine—in fact, hardware additions are so superficial that P&W claims a civilian version of the J57 can be converted to a turbofan in the field. Here's how the turbofan compares with the JT3C-7, P&W's designation for the commercial version of the J57:

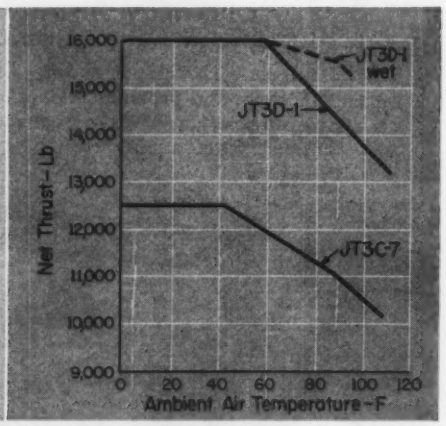
- 13% lower specific fuel consumption
- 33% more take-off thrust
- 13% more cruise thrust
- 15% less weight per lb thrust
- 10-20 db quieter in operation

Because of this high level of performance, the U. S. has ordered turbofan engines for the B-52H.

Housings for the new compo-

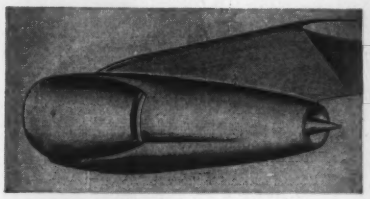


Runway length demanded by present jets has alarmed FAA. Turbofan engines will make possible taking off with the same payload from shorter runways. Altitude required over populated areas will be achieved more quickly.



Loss of take-off thrust in summertime temperatures is a great concern of jet operators. At 100 F the turbofan still has over 13,000-lb thrust. Water injection improves high-ambient-temperature performance.

nents were a routine job—except for the added problem of routing the "bypass" air. An earlier English bypass engine, the Rolls Royce Conway, ducted the bypass air the full length of the engine and dumped it into the exhaust. Objection to this system was the unavoidable friction loss that came from the long duct. Wind-tunnel tests showed that a short duct dumping the air through slots just forward of the halfway mark on



Nacelle with side slots for exit of bypass air showed high degree of aerodynamic efficiency in wind-tunnel tests.

the engine nacelle gave the most efficiency. Increase in nacelle drag was too small to measure. Annular pattern of the flow is interrupted only by the mounting pylon above and accessory drives housing below.

Inner parts of fan blades do the work of the missing J57 compressor stages. Outer blade sections form the giant fan that gives the converted engine half its thrust. The designer borrowed from his knowledge of turbine-blade design in specifying an integral shroud section to be forged with the blade at two thirds of its span from the hub. These sections fit together into a ring that helps control vibration in the long blades.

A total of 2.4 times as much air passes these blades as is handled by the original J57 blades. This demands more work from the turbine. Very little design work was needed to produce long, thin blades for the enlarged third turbine stage.

The shaft of the low-compressor spool was strengthened to take the added load, and water injection was added to minimize the effects of high ambient temperature. Resulting economy and high performance will solve many of the problems plaguing commercial jet users.

CONSIDER THE VITAL HYDRAULIC **C•ZONE**

GOOD DESIGN IDEAS COME TO LIFE WHEN THE CONTROL ZONE IS WATERMAN

A bright design idea!—a ditching machine with hydraulic-powered crowding, controlled independently of the ditching wheel and the spoil conveyor. And it comes to life with Waterman Series 1407 Flow Regulators in the *Control Zone*. Rated for pressures to 3000 p.s.i., and for *controlled* flow rates to 40 g.p.m., Series 1407 Flow Regulators are ideal for the control of hydraulic motors. A 180° turn of the calibrated handle provides a turndown of as much as 80 to 1, with precise, pressure-compensated flow control at any setting. Also available for panel mounting and manifold mounting.

Series 1407 is just one of many Waterman types that make up the most complete line of hydraulic flow regulators—fixed and adjustable. Specify Waterman for flow control and be *right—from the start.*

Waterman Valves and Accessories for Hydraulic Systems

Flow Regulators

Solenoid Valves

Filters

Check Valves

Pilot Checks

Waterman representatives are in all principal cities. Write for Waterman Flow Regulator Catalog No. 1001, and for Waterman Solenoid Valve Catalog No. 2000.

W-5915

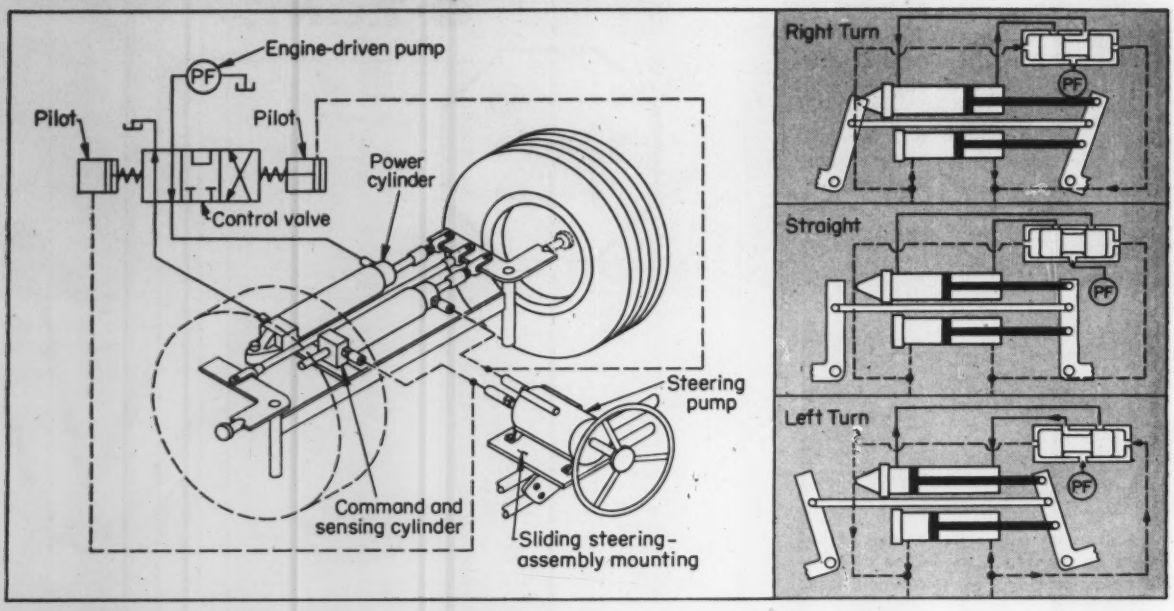
Also suppliers of AN and MS qualified flow regulators and fuses.

Waterman Engineering Company, 725 Custer Ave., Evanston, Illinois

WATERMAN ENGINEERING COMPANY

Circle 416 on Page 19

Floating Wheel Steers Off-Highway Vehicles



Steering wheel on a track moves laterally to any cab position in Vicker's new all-hydraulic power-steering system. This arrangement gives more freedom to the driver craning to watch close clearances on the off-wheel side. Because the steering linkage is mechanically free of the steering wheel, shocks of off-the-road travel are not felt through steering wheel. Turning the steering wheel operates a small hydraulic pump in its hub and raises pressure in a command cylinder. Spool valve, actuated by command-cylinder pressure buildup, directs engine-pump oil to the control cylinder operating the steering linkage. In case of power shutoff, the manual steering-wheel pump generates enough pressure to steer the vehicle through command-cylinder linkage. A relief valve limits pressure buildup.

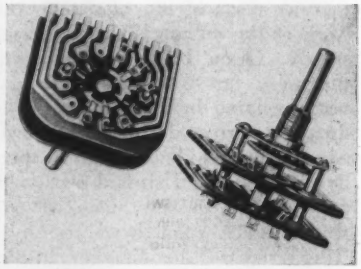
Tomorrow's Computer May Think For Itself

PARIS, FRANCE—Artificial intelligence may yet be created. In a paper before the International Conference on Information Processing, an American authority predicted a machine could be built to duplicate the human brain—at least in its ability to "learn."

Dr. D. G. Willis, Lockheed Missiles and Space Division, Sunnyvale, Calif., has developed a mathematical model of the human brain cell. The model and the theory on which it is based might pave the way to construction of a real thinking machine.

Willis' theory of the neuron (brain cell) postulates that changes take place in individual cells when they are excited, and that the changes have a permanent effect on the way cells will react to future excitation. These changes in behavior would explain how responses of cells are altered by their past history. By retaining this record, they would function as memory units.

Of the many remarkable properties of human memory, said Dr. Willis, there are two characteristics which are particularly noteworthy: Its tremendous storage capacity, which dwarfs that of the largest and most advanced computers; and its "random-access" ability to recall millions of bits of stored information, almost at demand. In an experiment with cells simulated on a digital computer, memory properties can be demonstrated. A given mode of excitation forces the cells to respond in a particular pattern. "But as we force more and more patterns with other excitations, they begin to interfere. The interesting thing . . . is not how many independent patterns can be read in and out again, but is in the way these patterns interfere with one another." This is not unlike the way in which memories may be associated in the human brain.

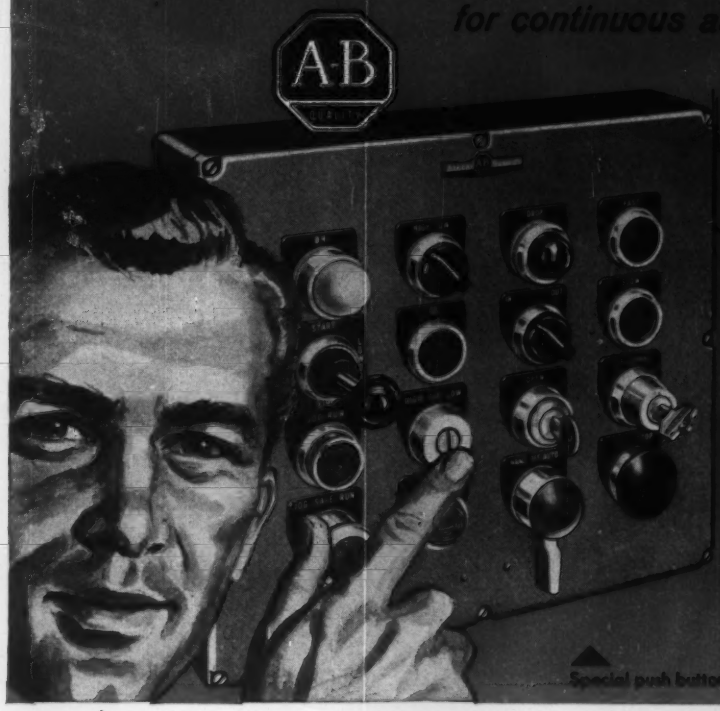


Printed-Circuit Switch Cuts Wiring Costs

Printed-circuit switch designed by Centralab Division, Globe-Union Inc., Milwaukee, reduces costs and eliminates wiring errors. All switching leads are connected simultaneously by dip soldering of etched circuit boards. No hardware is needed for rigid anchoring of the switch to the board. Constructed of laminated phenolic sections, the switch is available with bolted construction multiple sections and staked single or dual section assemblies. Combinations from one pole-12 positions through 6 pole-2 positions are offered in several switches.

AUTOMATION BEGINS HERE

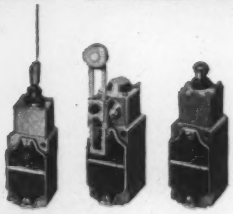
. . . Insist on Allen-Bradley accessories for continuous automatic production



In this broad line of Allen-Bradley accessories, each and every unit carries the traditional A-B trade-mark of *quality* that stands for trouble free operation. Rugged construction, and maintenance free, silver alloy contacts provide the reliability that is essential to the continuous operation of *your* automatic production machines.

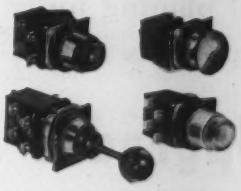
Profit from the experience of the leading machine tool builders . . . insist on Allen-Bradley *quality* motor control *all the way!*

Special push button panels can be assembled to your specifications.

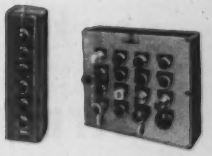


OILTIGHT LIMIT SWITCH
Bulletin 802T with sealed heads and bodies. Various operators.

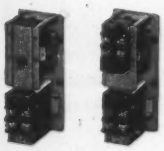
PRECISION LIMIT SWITCH
Bulletin 802 oiltight. Responds to very small operator travel.



OILTIGHT CONTROL UNITS
Bulletin 800T. Choice of push buttons, lights, and switches.

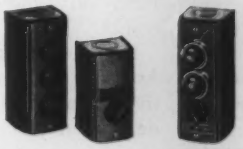


OILTIGHT CONTROL STATIONS
Bulletin 800T for up to 16 units in die cast aluminum enclosure.

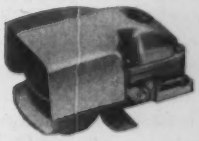


PNEUMATIC TIMERS
Bulletin 849. Reliable and accurate. For on-delay or off-delay.

OILTIGHT PRESSURE CONTROL
Bulletin 836. For hydraulic systems with pressures to 5000 psi.



STANDARD DUTY PUSH BUTTONS
Bulletin 800. Up to three units, also pilot lights and switches.



FOOT SWITCH
Bulletin 805. In rugged die cast housing for toughest service.

ALLEN-BRADLEY
Member of NEMA

QUALITY MOTOR CONTROL

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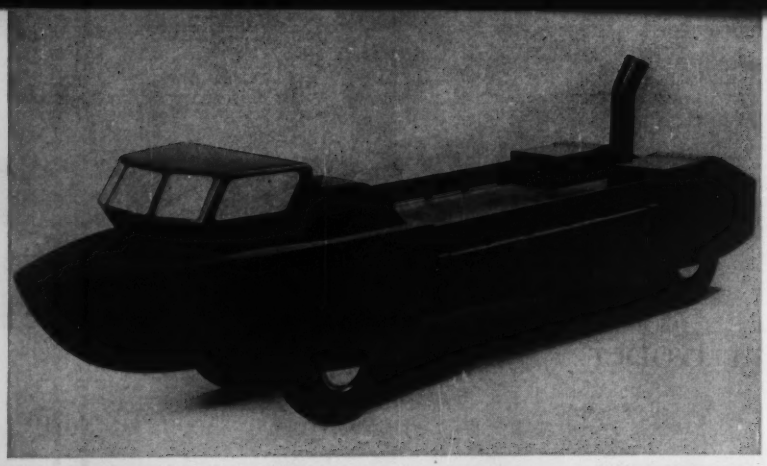
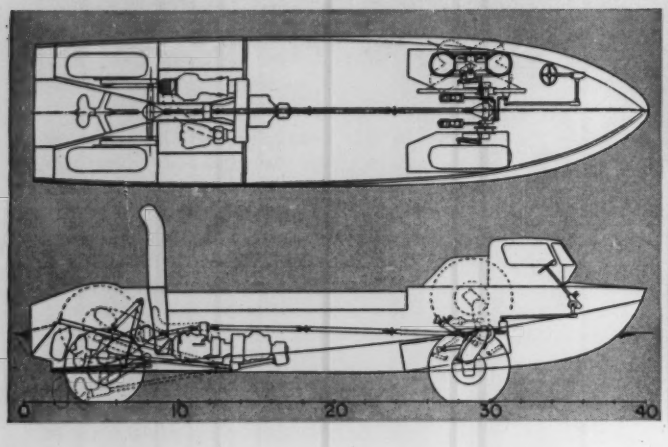
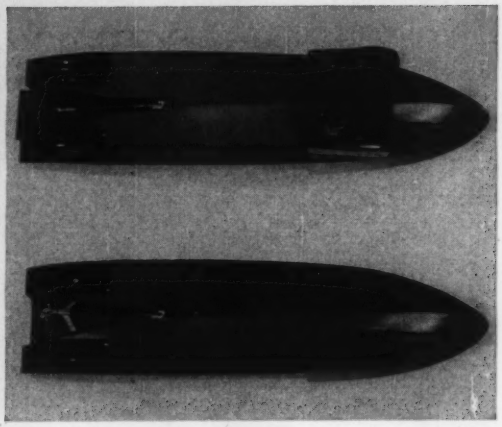
Circle 417 on Page 19



Powered by two gas turbines (250 hp and 1000 hp), the proposed Seahorse II is both a 5-ton 4 x 4 and a V-bottom planing amphibian. Top speed on land (250 hp) is about 35 mph. At sea, the fully loaded Seahorse will travel 30 mph (1100 hp). Propeller and wheels are fully retractable, and the vehicle has disc brakes, chain drive, and rear suspension only (soft tires on front). Over-all length is 40 ft; width, 10½ ft. Alternate powerplant for Seahorse—a 1000-lb, 1000-hp Italian V-12 engine—is under evaluation.



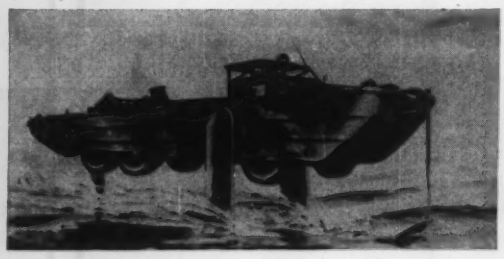


Turbines and planing hulls are key components as . . .

Army Upgrades Amphibious Vehicles

IN ANY WAR short of an all-out nuclear conflagration, the military will still face the basic logistical problem of getting supplies from ship to shore to frontline troops in the least possible time. The 16-year old amphibious Duck, designed around a 2½-ton GMC truck, shouldered the burden through World War II and Korea. The vehicle has earned a distinguished record, but is now considered too small and too slow to meet the fast-breaking events of atom-age "police actions." Army wants an amphibian that can speed bigger payloads through any kind of sea and perform on land with the best of trucks.

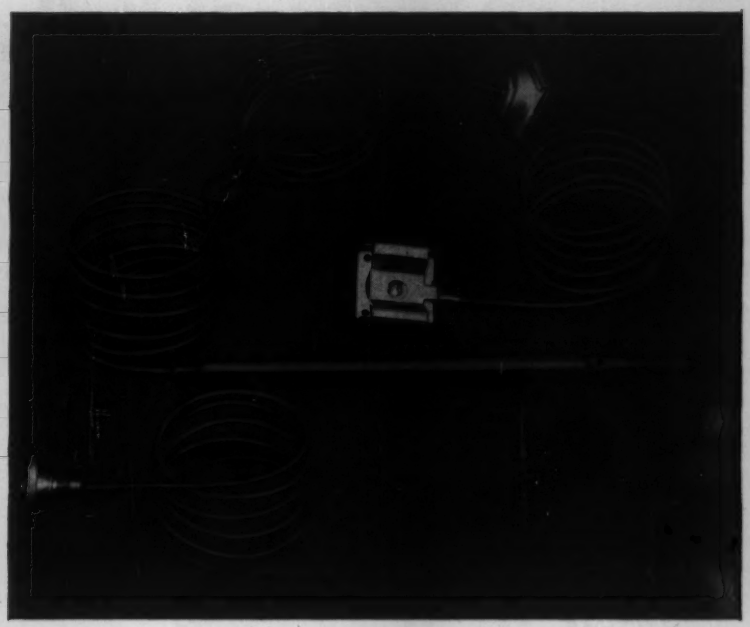
Engineers at Army's Detroit Arsenal (Ordnance Tank-Automotive Command) are well along in developing just what the assault experts want. Seahorse and Drake are two of their new vehicles that look especially promising. And this month, OTAC engineers will launch a Hydrofoil version of the old Duck, which may put new life in



Duck out of water, a hydrofoil version of World War II's veteran amphibian, will be launched this month by OTAC engineers. Addition of foils and a Lycoming T-53 shaft-turbine engine will boost Duck's present 6-mph water speed to a respectable 35-40 mph.

10 TO 15 NEW JOBS a week, each

a different application, require a continuous program of evaluating the properties of metals and fabricating costs at Robertshaw-Bridgeport.



In making bellows (left) and temperature sensors (above) to meet ever-changing needs of control, appliance, and industrial equipment manufacturers, Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co., Milford, Conn., averages 10 to 15 new problems a week. Specifications vary widely in dimensions and physical characteristics. Dependable performance over long periods of uninterrupted service is vital—yet costs must be rigidly controlled.

So for quality with maximum economy in fabrication, materials must be matched precisely to the needs of each job. And in this, Robertshaw-Bridgeport looks to its suppliers for creative technical services. For many years, The American Brass Company specialists have been helping to select the correct alloys in phosphor bronze or brass and to meet fabrication problems in the making of bellows—to apply economically precision-made capillary tubing and other small-diameter copper tube in sensor assemblies. Through such services, The American Brass Company is constantly helping metal fabricators across the nation control quality while keeping costs down.

ARE you caught between cost reduction and quality control? Find out if you are buying metal properties you don't need. An Anaconda specialist may be able to suggest a lower cost alloy that fits the requirements of your job more closely. Or he may find that an adjustment of temper or a change in your fabrication methods can cut your costs. The services of Anaconda specialists are available through your American Brass representative. Call him in today, or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5887

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COPPER BRASS BRONZE NICKEL SILVER

MILL PRODUCTS

Made by The American Brass Company

Circle 418 on Page 19

Bullet after impact
Too tough for bullets . . . Cutler-Hammer Molded Magnet Coils work perfectly even after being struck by rifle bullets. What better proof Cutler-Hammer Motor Control can withstand the most punishing service?
Too tough for boiling oil . . . The performance of Cutler-Hammer Molded Magnet Coils remains unchanged even after being boiled in oil. Further proof Cutler-Hammer Motor Control stops trouble before it can start.
350°F
PROOF
OF DURABILITY

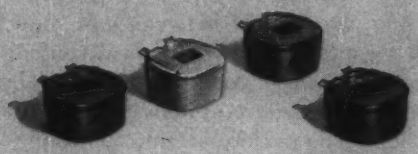
Cutler-Hammer Three-Star Motor Control is built to take it

If a rifle bullet can't pierce or shatter the Cutler-Hammer Molded Magnet Coil, what chance is there of it being punctured when an electrician's screwdriver slips or of it being damaged when the coil is dropped? If the Cutler-Hammer Molded Magnet Coil is impervious to boiling oil, what chance is there it can ever be penetrated by moisture or distorted by high ambient temperatures?

The strength and durability of these Cutler-Hammer Molded Magnet Coils are but one example of how Cutler-Hammer Three-Star Motor Control is built to take it. Why settle for less when Cutler-Hammer Control costs no more? Specify Cutler-Hammer Three-Star Motor Control . . . you can be sure it installs easier, works better, and lasts longer.

COLOR-CODED FOR RAPID, SURE IDENTIFICATION . . . No guesswork for electricians or stock men. Each color signifies the coil's voltage and frequency. Colors are permanent, too, can't rub off.

RED—110 volts A-c, 60 cycle
GREEN—208/220 volts A-c, 60 cycle
YELLOW—440 volts A-c, 60 cycle
BLACK—all other voltages and frequencies



CUTLER-HAMMER

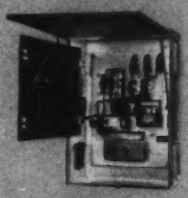
Cutler-Hammer Inc., Milwaukee, Wis. • Division: Airborne Instruments Laboratory. • Subsidiary: Cutler-Hammer International, C. A.
Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

CUTLER-HAMMER CONTROL C-H

Molded magnet coils are standard in all Cutler-Hammer Three-Star Motor Control

NON-REVERSING STARTERS AND CONTACTORS

CONTROL RELAYS



OIL WELL PUMPING CONTROL

REVERSING AND MULTI-SPEED STARTERS AND CONTACTORS

UNITROL MOTOR CONTROL CENTERS

AND MORE...

Write today for Pub. EN150-N243. Cutler-Hammer Inc., Milwaukee 1, Wisconsin

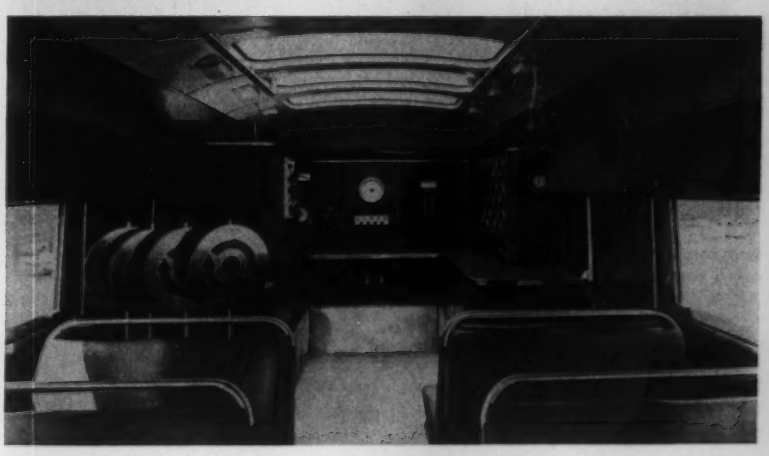
the battle-scarred veteran.

According to OTAC project engineer Herman Nadler, a basic objective in the amphibious program is to give each vehicle a multiplicity of uses so that many other single-purpose vehicles can be eliminated. For this reason, the new amphibians will be capable of ranging far inland to serve as mobile gun and missile platforms as well as troop-cargo carriers.

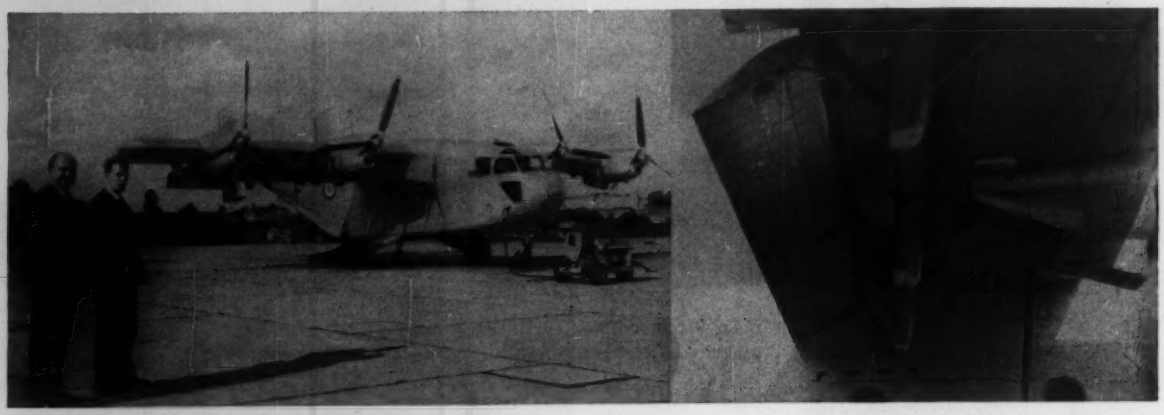
A Biggest Amphibian in service, with exception of Army's shore-limited Bark, is the 10-ton, 8 x 8 Drake. Present version, now under evaluation by various British and American services, is powered by two 6-cyl, 155-hp Chevrolet engines. Land speed is 44 mph; water speed, 12 mph. Power train includes two torque converters; eight torque-proportioning differentials. Drake can negotiate a 20-ft surf, has much better off-highway capabilities than a conventional highway truck.

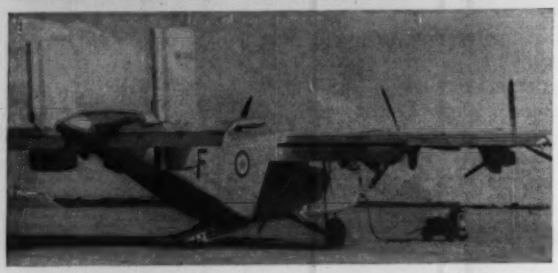
Rolling Lab Gathers More Data

Classroom laboratory on wheels will be used by the University of Michigan for automotive research and for training student engineers in road-test instrumentation. The custom-built laboratory, donated by International Nickel Co. Inc., has space and instrumentation aboard to accommodate 18 students; twenty special instruments, many of them developed for this vehicle, have been installed to contribute data for a wide variety of tests under road conditions. The engine bed is designed for installation of experimental turbine, diesel, and gas power plants. A new type sintered-plate, nickel-cadmium battery will meet lab power demands, permit study of subzero starting.



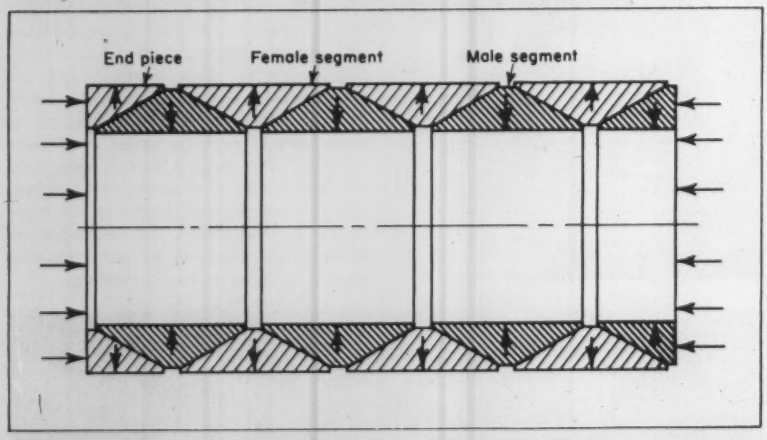
Props Geared to Common Shaft in New STOL Aircraft





Feathering is unnecessary if one engine fails on the four-engine Breguet-Piasecki 940 STOL. A common shaft geared to the engines' free turbines drives all four props on the French-designed craft. This adds a big margin of safety, especially during transition from vertical to horizontal flight, when complete loss of power from one engine would be critical and momentary feathering would be impossible. Deflected slipstream obtained from big flaps, above right, gives the 940 good short-takeoff and landing performance. The 7-ton craft can clear a 50-ft obstacle in less than 350 ft on takeoff; it lands within 250 ft. Piasecki Aircraft Corp., Philadelphia, will assemble the 940 in this country.

Adjustable Wall Makes Close-Fit Bushing



Close-tolerance fits in standard holes are possible with a new split-ring bushing that has adjustable wall thickness. It permits use of a standard bolt as a structural fastener, hinge pin, or in place of taper or press-fit pins. An axial pinch forces bushing segments to ride over each other in a wedging action. This increases the OD of female segments while at the same time reducing the ID of the male segments. Developer, Globe Bushing Corp., North Hollywood, Calif., says a variety of bushing materials makes possible applications like plain bearings, shaft clamps, or shaft packing from standard stock.

Supply and Demand Still Favors New Engineering Graduates

WASHINGTON, D. C.—Labor Secretary James P. Mitchell sees the job picture for the 1959 crop of engineers as "very good." Mechanical, electrical, and aeronautical engineering graduates seem to have a slight edge on civil, chemical and industrial engineering majors.

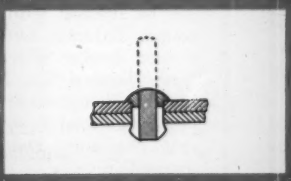
Employers showed greater selectivity in their campus-interview wooing—students who finished at the lower end of the class may find it necessary to go out and look for jobs.

Starting salaries, which tended to level off in 1958, are rising once more. Within five years, engineering graduates will start at $700 a month, says Donald Moyer, Cornell University's director of student personnel. Mr. Moyer also believes that decreased engineering enrollment will be a general trend. He blames the decline on both the 1958 recession and the satellite-era "glamorization" of scientists, which has resulted in a shift in emphasis from engineering to science.

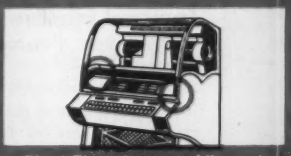
time-saving, neat-appearing **FASTEX®**

Plasti-Rivets®

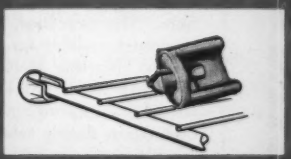
JUST SET . . .



. . . AND DRIVE



Plasti-Rivets fasten molding onto coin-operated machines, are available in colors to complement product color scheme.



The Plasti-Rivet principle has been incorporated in Plasti-Supports (TM); form ideal refrigerator shelf-supports.

Circle 420 on Page 19

Molded of thermoplastics, Plasti-Rivets fasten from one side with a single blow. The prongs expand when the integrally molded pin is driven, providing a positive, vibration resistant lock. Blind assembly is simplified, products improved and time saved while costs are reduced. Plasti-Rivets can withstand a direct shear of up to 500 pounds. Available in a choice of decorator colors and shapes, Plasti-Rivets will never mar or scratch your product's surface. For a firm, positive fastening, specify easy-to-use Fastex Plasti-Rivets.

Write for your free sample packet and informative brochure listing 25 standard Plasti-Rivets. See how simple and economical blind fastening can be.

Fastex Plasti-Rivets Create Assembly Savings in: non-conductive fastening of electrical products, name plate attachments, appliance shelf fastening, rustproof fiberglass awning fastening, and color-matched fastenings for practically any product.

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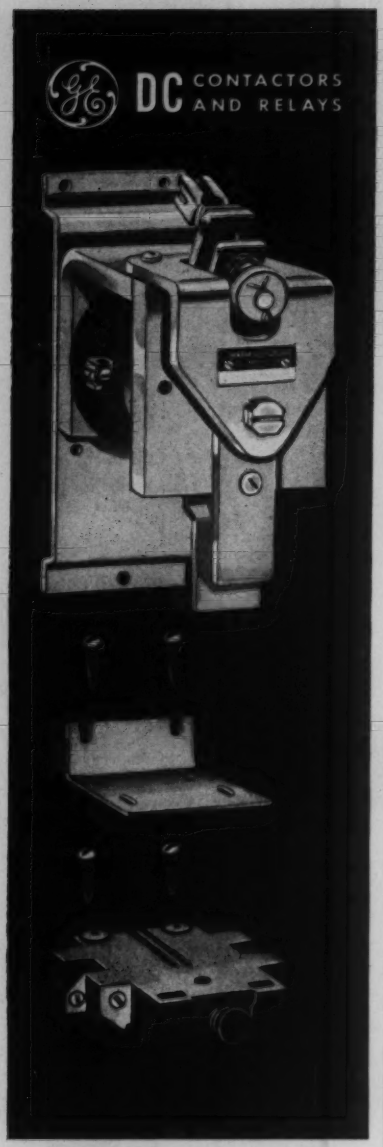

NEW BUILDING-BLOCK DC DEVICES

Assemble the exact contactor or relay you need—when you need it! General Electric's new "building-block" design allows quick, on-the-spot assembly of more than 100 different devices—from a few standard components. For all the facts, follow reader service instructions below. General Electric Company, Roanoke, Virginia. 784-19

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 421 on Page 19

Coil and Foam Come to Grips

Combining the best features of each, a new car seat molds coil springs and foam rubber in an integral unit. Reynolds Chemical Div., Stubnitz Greene Corp., Whitmore Lake, Mich., says pilot models are being tested, and plant production is expected to be under way in time for use of the new type seat in 1960 model cars.

Shelved Patents Will Be Put To Work by New Firm

WASHINGTON, D. C.—Several hundred million dollars' worth of research and development—neatly documented in U. S. patents—is tucked away in filing cabinets throughout the country. Seeking to put some of these sidetracked but still valuable patents, processes, and ideas to work, a new company will act in a middleman capacity between patent holder and potential developer.

National Patent Development Corp. will help owners of patents and processes to find concerns that will manufacture the item or develop the process. Corporate clients will be aided in selling or licensing patents and ideas which do not have a natural outlet within their own operations. Expected results of such new-product promotion are stimulation of the growth of new industries and markets and increased competition in certain industries.

Offices of National Patent Development Corp. will be in Washington, D. C., and New York City. Jess Larson, former Federal Works Administrator and Chief of the War Assets Administration, is chairman of the board.

Metals Matters

Aluminum coat . . .
is deposited on a wide range of metals by a new vacuum coating process developed by National Research Corp., Newton Highlands, Mass. The ductile, nonporous coatings may be anodized for excellent wear resistance and attractive coloring in a full spectrum of tints and shades.

Beryllium wire drawing . . .
has proved successful with standard drawing equipment and a special preheat furnace. Preliminary tests by Brush Beryllium Co., Cleveland, show that it is now possible to draw 0.090-in. pure beryllium wire from 0.250-in. rod. A research project on this subject is intended to produce wire of good mechanical properties and to develop further basic information on the working and heat treating of beryllium. The most critical variables seem to be temperature, die design, crystallography, and composition of starting materials.

Magnesium-rare-earth alloy . . .
can be sand cast to combine good tensile properties at temperatures ranging from room-temperature to 600 F. Creep resistance is excellent at 600 F for up to 10 hours, and at 450 F for up to 1000 hours. Further, the alloy reportedly has twice the strength of light metals at 500 F. In addition to castability, the alloy can be welded by argon-arc or heli-arc methods, and can be finished with standard magnesium finishing systems. It is also a good forging alloy. Developed by Dow Chemical Co., Midland, Michigan, the composition is 3.2 per cent rare-earth metal (didymium), 0.6 per cent zirconium, and the remainder magnesium.

Structural beryllium . . .
in sheet form has been produced by Martin Co., Baltimore, Md., for use in airframe structures. Space vehicles using the material may not need special cooling devices to solve re-entry problems. Beryllium is superior to other metals in strength, stiffness, heat absorption, and lightness of weight, but use has been limited by nonuniform properties and glass-like brittleness. The new sheet has homogenous properties suitable for structural fabrication. Nuclear Metals Inc., working with Martin, solved the problems involved by controlling crystal size and orientation during fabrication.

Circle 422 on Page 19→

WESTERN CONTROL CORP.

achieves three-way control with KEYSTONE WIRE

At their modern plant in Wichita, Kansas, Western Control Corporation produces flexible controls that are specified for many applications from lawnmowers to giant excavators. This wide range is the result of closely controlled quality and cost at Western Control. Western has successfully used Keystone MB Spring Wire since its inception in 1946. Here are some reasons they give:

CONTROL OF PRODUCTION — Keystone metallurgists worked with Western and developed a special quality of drawn galvanized spring wire for high speed coiling. Constant uniformity of MB Spring Wire means long production runs — increased productivity of machinery.

CONTROL OF QUALITY — Company officials report, "Uniformity of temper and size of Keystone MB Spring Wire gives us close inside and outside diameter tolerances. Coating, too, is superior — no flaking or stripping in the manufacturing process."

CONTROL OF COSTS — Keystone furnishes drawn galvanized MB Spring Wire to Western in pay-off packs. This means less waste — less set up time — less handling time — and cleaner wire. To Western, this means a quality product at a competitive price.

Could you benefit from our experience in solving difficult wire problems? Talk it over with your Keystone Wire Representative.

Keystone Steel & Wire Company, Peoria 7, Illinois

KEYSTONE

WIRE FOR INDUSTRY

Assembly costs cut 50% at design stage by Tinnerman **SPEED NUT**® Brand Fasteners!

Fastener ideas worked out between designers at Hillside Metal Products, Inc., and Tinnerman engineers, resulted in the selection of 3 different SPEED NUT types for Hillside's complete line of quality steel office furniture. Hillside estimates "at least a 50% saving in material costs, assembly time and tooling" over ordinary fastening methods. And spring-steel SPEED NUTS hold tight, even through years of hard service.

A special Dart-Type SPEED CLIP® snaps into a punched hole, securely anchors one end of the drawer latching mechanism spring. A standard Push-On SPEED NUT "bites" into a stud; prevents the other spring end plus latching bar from backing off. Desk tops as well as desk and table legs, are attached with the help of SPEED GRIP® Nut Retainers that snap into bolt-receiving position in punched holes. A Push-On completes the file drawer follow block assembly; two more secure each filing cabinet drawer card holder.

This should give you an idea of what a free Fastening Analysis can probably do for you in savings and improvements on present or new products. Look up your Tinnerman representative in the Yellow Pages under "Fasteners". Or write to

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Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

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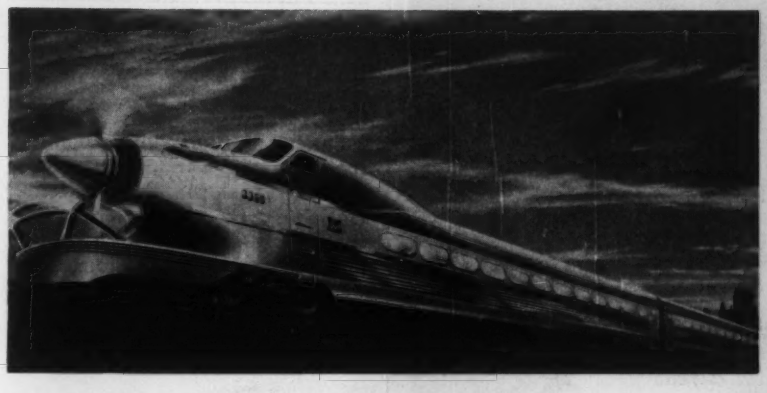
CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.



Crack Flyer Uses Air Power

Aerodynamics train model, engineered by Wright Aeronautical Div., Curtiss-Wright Corp., Wood-Ridge, N. J., will be shown at world fairs this summer. Wright claims propeller-driven train will save up to ten hours on Chicago to Los Angeles run. Other advantages are better traction in bad weather, positive braking from reversible-pitch propellers, and weight saving from aircraft-type engine.

Meetings and Shows

July 13-17—

National Association of Power Engineers. National Convention to be held at the Statler Hotel, Boston. Further information is available from association secretary, Edward J. Schuetz, 176 W. Adams St., Chicago 3, Ill.

Aug. 9-12—

American Society of Mechanical Engineers - American Institute of Chemical Engineers. Heat Transfer Conference to be held at the University of Connecticut, Storrs, Conn. Further information may be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Aug. 10-13—

Society of Automotive Engineers Inc. International West Coast Meeting to be held at the Hotel Georgia, Vancouver, B. C., Canada. Additional information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Aug. 17—

Institute of Radio Engineers. First National Ultrasonics Symposium to be held in San Francisco. Further information is available from IRE, 1 E. 79th St., New York 21, N. Y.

Aug. 18-21—

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Sponsors are Western Electronic Manufacturers Association and the Seventh Region of the Institute of Radio Engineers. Further information can be obtained from WESCON headquarters, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Aug. 31-Sept. 2—

Army-Navy Instrumentation Program Symposium and Industry Briefing to be held at the Statler Hilton Hotel, Dallas. Further information can be obtained from G. Jackson Butterbaugh, Asst. Director of Public Relations, Bell Helicopter Corp., P. O. Box 482, Fort Worth 1, Tex.

Sept. 1-3—

Association for Computing Machinery. 14th National Conference to be held at Massachusetts Institute of Technology, Cambridge, Mass. Additional information is available from Dr. Frank M. Verzuh, Computation Center, MIT, Cambridge, Mass.

Sept. 7-11—

Illuminating Engineering Society. Annual National Conference to be held at the Fairmont and Mark Hopkins Hotels, San Francisco. Further information can be obtained

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➤ over-the center positive action
➤ flush when closed
➤ seals against internal and external pressure
➤ protects against dirt and moisture
➤ fail-safe construction
➤ aromatic fuel resistant
➤ 1 to 1-¾ oz. weight

Missile-Air latches are in use on jet aircraft, missiles and electronic equipment under the most severe environmental conditions. They cannot fail under stress or vibration. Fingertip opening or closing without tools greatly speeds servicing. *Sensibly priced for any application.* Many types to choose from or special design on request.

Send for complete technical information to:
1700 Rosecrans Boulevard, Manhattan Beach, California.

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Circle 424 on Page 19

It's lots more fun...

Jim always came home grouchy and complaining about noisy gears and how did they expect him to build precision machines. But ever since the day he said they gave him a real batch of gears, made to order by CINCINNATI GEAR . . . he's my boy!

When it comes to gearing in your product, remember this **profit formula:**

Modern Manufacturing + Old-time Craftsmanship + Precision Inspection = CINCINNATI gears

For guaranteed custom gears and custom gear boxes, send your prints for our quotation.

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THE CINCINNATI GEAR CO.

Wooster Pike and Mariemont Ave. Cincinnati 27, Ohio
Custom Gear Makers Since 1907

GEARS, good gears only

from IES headquarters, 1860 Broadway, New York 23, N. Y.

Sept. 14-17—
Society of Automotive Engineers Inc. National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display) to be held at the Milwaukee Auditorium, Milwaukee. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Sept. 17-18—
American Society of Mechanical Engineers—American Institute of Electrical Engineers. Engineering Management Conference to be held at the Statler Hilton Hotel, Los Angeles. Additional information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 20-23—
American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Rice Hotel, Houston. Further information is available from Meetings Dept., ASME, 29 W. 39th St. ,New York 18, N. Y.

Sept. 20-25—
Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Pal-

"I want Finchley to start at the bottom, so I'm putting him in charge of this department."

mer House and the International Amphitheatre, Chicago. Additional information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 21-22—

Steel Founders' Society of America. 57th Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 21-22—

Standards Engineering Society. Eighth Annual Meeting to be held at the Somerset Hotel, Boston. Additional information can be obtained from Charles T. Ajamian, P. O. Box 538, Wayland, Mass.

Sept. 23-25—

American Institute of Electrical Engineers—Institute of Radio Engineers. Nonlinear Magnetics and Magnetic Amplifiers Conference to be held at the Shoreham Hotel, Washington, D. C. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 24-26—

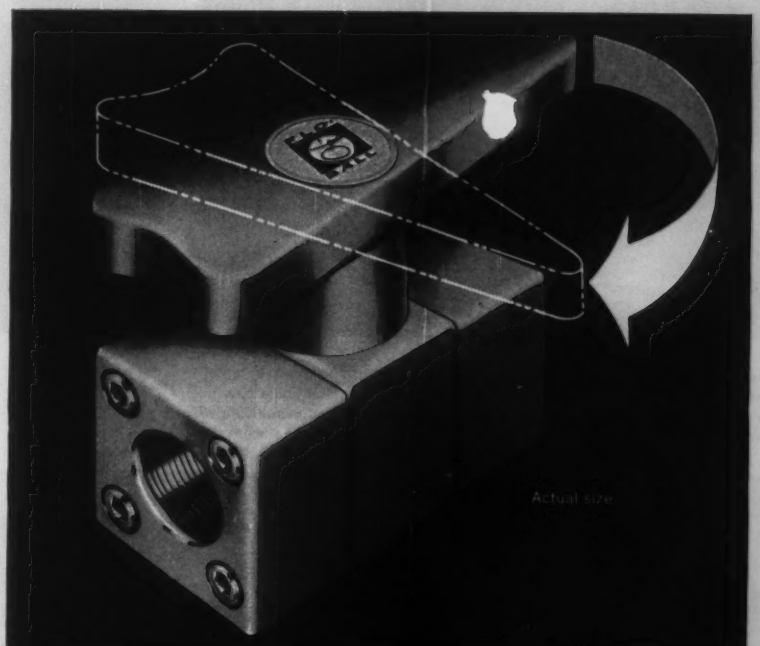
Porcelain Enamel Institute. Annual Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Further information is available from PEI headquarters, Associations Bldg., 1145 Nineteenth St. N.W., Washington, D. C.

Sept. 28-Oct.1—

American Society of Mechanical Engineers — American Institute of Electrical Engineers. National Power Conference to be held at the Muehlebach Hotel, Kansas City, Mo. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 30-Oct. 1—

Institute of Radio Engineers — American Institute of Electrical Engineers. Industrial Electronics Conference to be held at the Mellon Institute, Pittsburgh. Further information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.



Replace obsolete needle valves with the

NEW 90° ON-OFF

FLO-BALL

For 3,000 PSI...

Low torque, instant action . . . a fast 90° turn, requiring just 4 inch-pound torque at 3,000 psi, actuates the valve instantly!

Priced no higher than needle valves!

100% flow efficiency . . . straight-thru ***FLO-BALL*** design has more than twice the flow efficiency of needle valves!

Positive ON-OFF indication . . . large arrow-shaped handle shows valve position at a glance!

Zero leakage . . . Mass Spectrometer tests with Helium prove zero leakage!

Universal mounting . . . can be panel, side, bottom, or line mounted!

Removable flanges . . . damaged flanges can be removed in seconds; no need to replace entire valve!

All stainless steel construction . . . costs no more than old fashioned screw-type valve!

Versatile service . . . ideal for leak-proof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, and many other fluids.

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Port Styles and Sizes			
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Size	Part No.	Size	Part No.
⅛	715A1	¼	715A2
¼	715B1	⅜	715B2

Other models are available for service with cryogenic and corrosive media. Also special designs for throttling flow control.

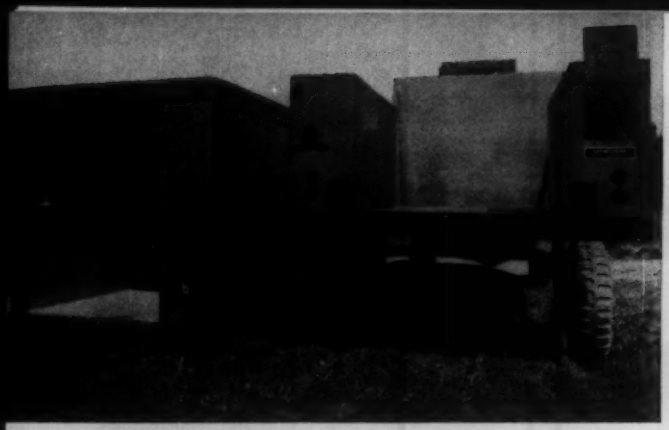
Write today for new catalog describing the world's most complete line of precision valves for industrial and military applications.

FLO-BALL

Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX=LIVINGSTON, N. J. 120

Circle 426 on Page 19



The Thompson Level-Loder raises and lowers to any height from curb side to 4½ feet. Hydraulic cylinders lift the body up and down in a vertical guide mounted on the truck cab. Thompson Trailer Corp., Pikesville, Maryland, a subsidiary of General American Transportation Corp., Chicago, introduced the new design.

It tilts . . .

. . it leans . . . . . it hunches up and down

Unique truck built lighter, stronger with USS COR-TEN Steel

Here's a truck body that acts like an elevator. With front wheel drive, it has no rear axle or drive shaft. Hydraulic cylinders tilt it forward, backward, sideways, and raise it up and down to any height from curb level to 4½ feet. This cuts loading time as much as 75% and makes unloading up to five times faster.

Because the main stress of the lift is concentrated at the wheel box housings, they have to be as strong as possible. And because the truck body is lifted along with the payload, the body has to be as light as possible. The entire body, including the wheel housings, was built with USS COR-TEN High-Strength Low-Alloy Steel because this grade meets the demands of both lightness and high strength. COR-TEN Steel's 50% higher yield point means it can be used in thinner and lighter gages, reducing weight as much as ⅓ with no sacrifice in strength. And it has high resistance to abrasion, atmospheric corrosion, impact and fatigue.

U. S. Steel produces three brands of High Strength Steel—COR-TEN, TRI-TEN, and MAN-TEN. Each has characteristics that make it ideal for special design applications. For complete information about these "steels that do more", write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. *USS, COR-TEN, TRI-TEN and MAN-TEN are registered trademarks*

USS

United States Steel Corporation—Pittsburgh
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Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
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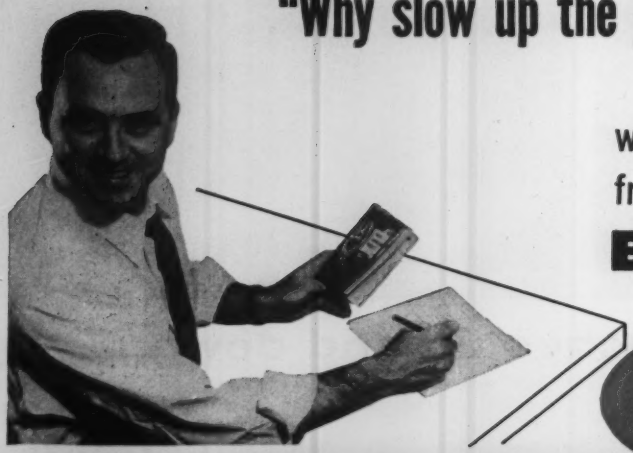

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from over 2000 standardized

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OFF-THE-SHELF
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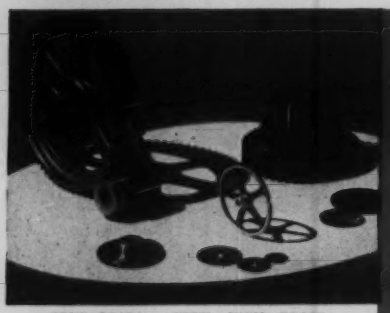
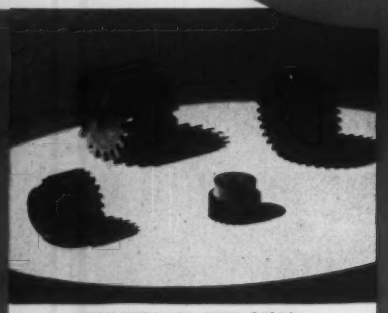
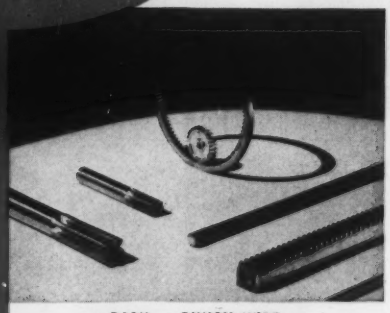


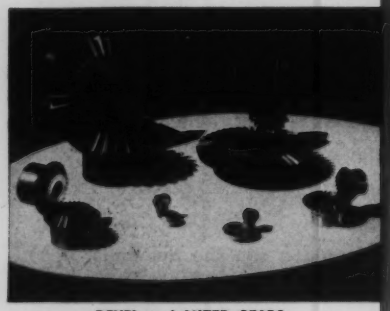
SPUR GEARS — STEEL, IRON, BRASS
14½° and 20° P.A. .208" to 40" P.D.



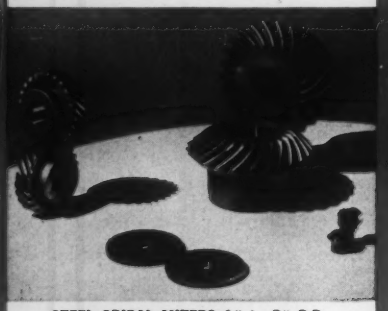
NON-METALLIC SPUR GEARS
14½° and 20° P.A. .938" to 6.667" P.D.



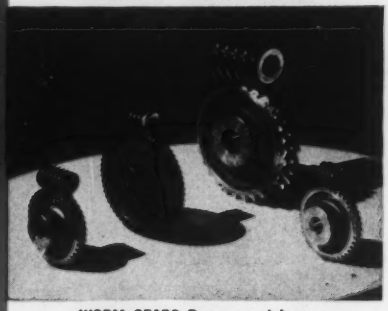
RACK • PINION WIRE
Steel and Brass 14½° and 20° P.A.
PINIONS • INTERNAL GEARS



BEVEL and MITER GEARS
Steel, Iron, and Brass 20° P.A.
.312" to 14" P.D.



STEEL SPIRAL MITERS 1" to 5" P.D.
HELICAL GEARS
Steel and Bronze .333" to 6" P.D.



WORM GEARS Bronze and Iron
.417" to 18" P.D. **WORMS** .333" to 4" P.D.
Soft Steel and hardened and ground steel

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STANDARDIZED TRANSMISSION PRODUCTS

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Take a good look through the BOSTON Gear catalog. You'll find standardized types and sizes to fit most of today's transmission needs. Why pay more (and wait) for gears made to order? Design around BOSTON Gear. It saves time and money in planning, in purchasing, in production . . . and you simplify servicing problems. Boston Gear Works, 64 Hayward Street, Quincy, Mass.

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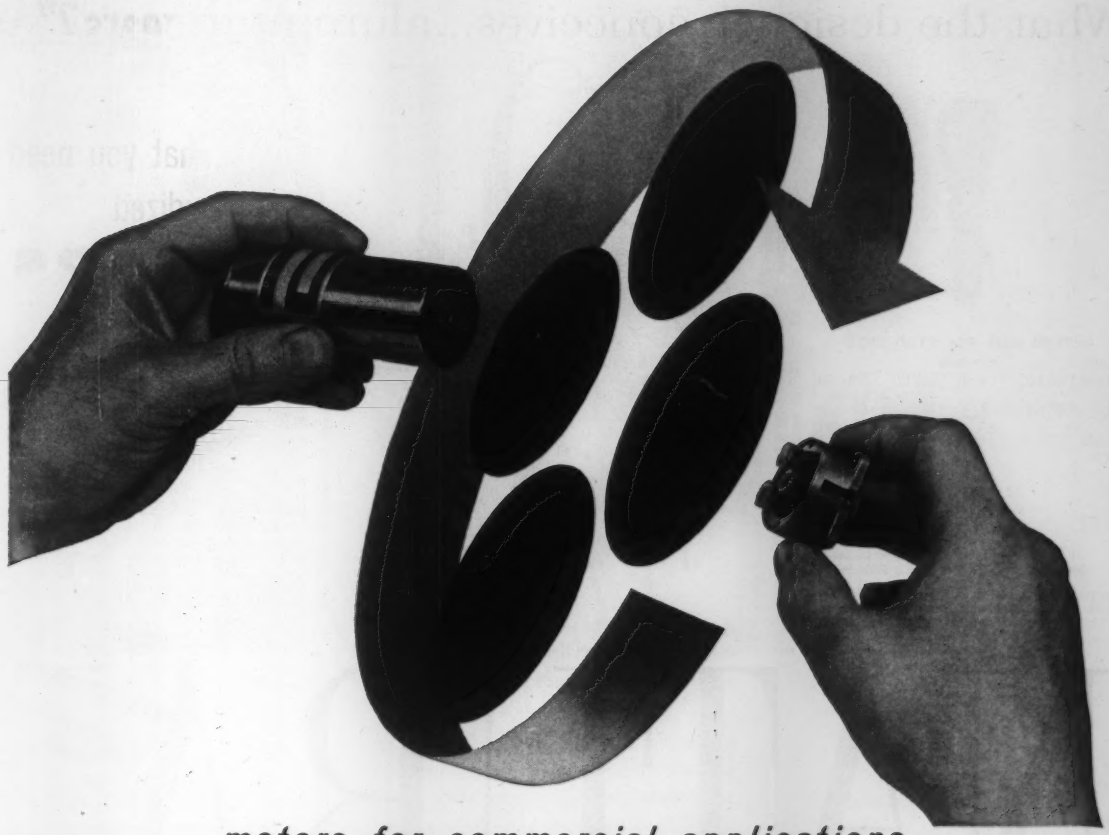


motors for commercial applications

HIGHEST TORQUE FOR SMALLEST SPACES

Missile designers are well acquainted with the extremely high torque available from a planetary geared precision miniature Globe motor. Units similar to the one pictured can produce up to 150 inch pounds of torque!

And more and more designers are finding that these motors offer outstanding advantages for commercial applications as well. Universal, a.c., or d.c. types are available from ⅞" to 2¼" in diameter. They can replace larger, ordinary motors at competitive cost, and deliver important bonuses too. They perform reliably under conditions that would soon ruin ordinary motors—high humidity and temperature, jarring shock and vibration, dust and fume-laden atmospheres.

Globe speed reduced motors are engineered to fit your specific application as no "off the shelf" motor can. Standard component design is the secret; for example, 83 even ratio planetary reducers are available to give the speed and torque you need. Many parts are inventoried. Design and production efficiency will save you money. If you have a commercial application that demands a smaller, more powerful, more reliable and competitively priced motor, then consult Globe first. Write for Bulletin ACG. Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE INDUSTRIES, INC.

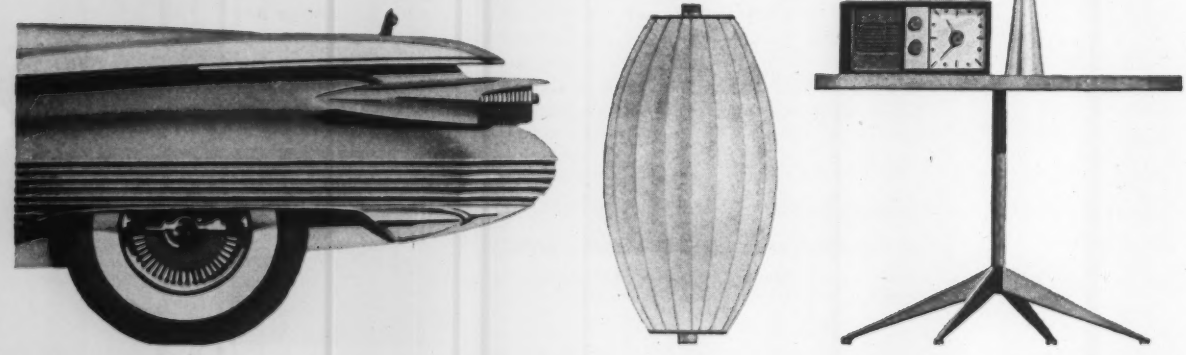
PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS. TIMERS. GYROS. STEPPERS. BLOWERS. MOTORIZED DEVICES

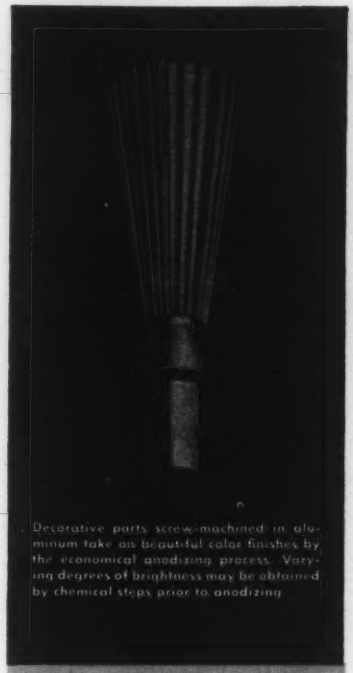
GLOBE

Circle 428 on Page 19

What the designer conceives...aluminum achieves

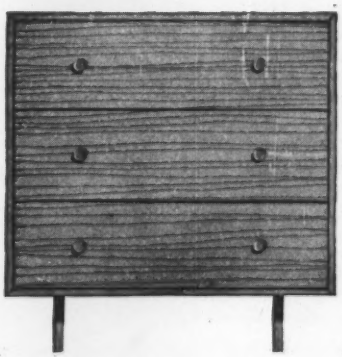
COLOR BEAUTY NATURAL BEAUTY





Decorative parts screw-machined in aluminum take on beautiful color finishes by the economical anodizing process. Varying degrees of brightness may be obtained by chemical steps prior to anodizing.

Clear-anodizing produces a jewel-hard coating that protects aluminum's natural silvery beauty—and at far less finishing cost than other processes such as plating or polishing.



AND SAVINGS WITH SCREW MACHINE PRODUCTS IN ALUMINUM

You save on material, you save on finishing, and you save on over-all cost when you design with aluminum! (See cost comparisons at right.)

As in the finished shapes shown, aluminum offers exceptional design versatility in the screw machine process... sharp, clean lines ... and unusually fine "as-machined" finish.

In the screw machine process, aluminum's excellent machinability makes possible production versatility. High production rates plus low tooling cost assure initial savings as well as model-change economy.

Aluminum offers still more useful properties, such as light weight with high strength, corrosion resistance, non-sparking and non-magnetic qualities.

Kaiser Aluminum does not manufacture screw machine parts, but does offer technical assistance to parts suppliers throughout the country. Contact your local screw machine products manufacturer for further information and quotations on specific parts in aluminum.

Kaiser Aluminum & Chemical Sales, Inc.
1924 Broadway, Oakland 12, Calif.

KAISER ALUMINUM

See "Maverick" • Sunday Evenings, ABC-TV Network
Consult your local TV listing.

COST DATA FOR 1000 PIECES*

	Aluminum	Brass
Material (53 lbs.)	$28.20	(159 lbs.) $52.66
Less 47% scrap (@ 18.5¢/lb.)	4.13	(@ 18¢/lb.) 13.50
Total Material Costs	$24.07	$39.16
Machining	11.80	11.80
Approximate Tooling Costs ($190)	1.90	1.90
Color Anodizing	10.00	
Total Cost	$47.77	$52.86

Total Savings per 1000 pieces $ 5.09 (In Aluminum)

(An unlimited number of metal bonded colors are available with aluminum—obtainable in other metals only by less durable surface coatings.)

COST DATA FOR 1000 PIECES*

	Aluminum	Brass
Material (73 lbs.)	$37.74	(218 lbs.) $88.85
Less 52% scrap (@ 18.5¢/lb.)	6.27	(@ 18¢/lb.) 20.34
Total Material Costs	$31.47	$45.71
Machining	25.65	25.65
Approximate Tooling Costs ($200)	2.00	2.00
Clear Anodizing	10.00	
Chrome Plating		15.00
Total Cost	$69.12	$88.36

Total Savings per 1000 pieces $19.24 (In Aluminum)

***(These are estimated costs based on runs of 100,000 pieces)**

Kaiser Aluminum & Chemical Sales, Inc.,
Dept. SM-1065
1924 Broadway, Oakland 12, California

Please send me the free "Color Beauty" booklet with cost data and color-anodizing information for aluminum screw machine parts.

NAME _____

COMPANY _____

ADDRESS _____

CITY _____

STATE _____

Circle 429 on Page 19

DYNAMIC DIFFERENCE

in hydraulic performance

Webster

DIRECTIONAL CONTROL VALVES

Combines to culvert cleaners — anywhere one, two or more hydraulic applications are handled at one time... *the difference is dynamically apparent when Webster is on the job!* Versatile! Parallel design permits control of up to 6 independent circuits. Range! Operating pressures to 2000 psi — shock pressures to 5000 psi. Lowest back pressure. Compact! Smallest size for rating. Three sizes — single spool type in 20 gpm capacity, parallel stacked in 20 and 40 gpm capacities.

You find Webster Directional Control Valves on leading agricultural, road building and industrial machines. Chances are there's a size and model ideally suited for your product — for the dynamic difference that pays!

DESIGNED FOR PEAK PERFORMANCE
• Alloy steel spools — heat-treated, precision-ground.
• Fully balanced at all pressures.
• Stack valves have throttling grooves in spools for smooth, gradual flow.
• Inlet and outlet connections can be made to the same end of the valve assembly to simplify hook up.
• Alternate porting positions provided for flexibility in application.
Call the man from Webster
... he's one of a staff of engineers, specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design!

OIL HYDRAULICS DIVISION

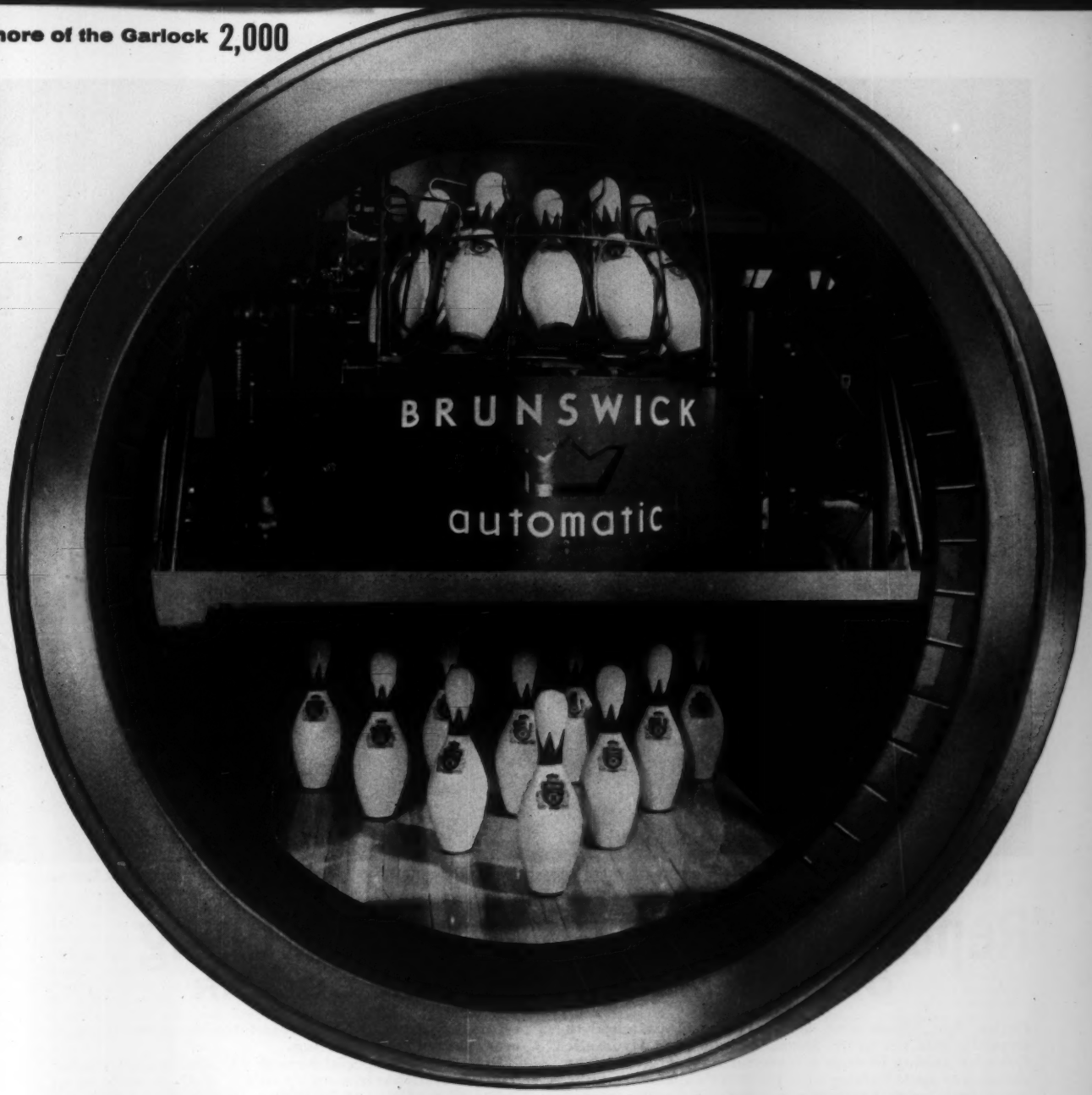
WEBSTER ELECTRIC

RACINE · WIS

our 50th year

Circle 430 on Page 19

more of the Garlock **2,000**



Garlock Seals "spare" pinsetters from loss of vital oil

Garlock Klozure* Oil Seals help assure dependable operation of Brunswick-Balke-Collender automatic pinsetters by eliminating oil leakage from the gear box. At the same time, they prevent damage to the bearings by sealing out dirt and dust.

Reliability is the prime reason for specifying Klozure Oil Seals, according to Brunswick. The Seals have been in continuous use for 3½ years!

Your product, too, can enjoy long, trouble-free life like this; simply design Klozures into your application. Standard Klozures are resistant to grease and oil . . . impervious to water, mild acids, alkalies . . . non-abrasive . . . applicable from −40° F to +250° F. For extreme service conditions, Klozures are available to withstand any fluid and temperatures as high as +500° F.

Klozure Oil Seals are another part of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Call your local Garlock representative, or write for Klozure Catalog 30.

*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals,
Molded and Extruded Rubber, Plastic Products

Canadian Division: The Garlock Packing Co. of Canada Ltd.
Plastics Division: United States Gasket Company

Circle 431 on Page 19

Dynex, Inc., Pewaukee, Wisconsin, produces single- and double-acting cylinders from Republic ELECTRUNITE Special Smooth I.D. Hydraulic Cylinder Tubing.

Republic ELECTRUNITE Tubing . . .

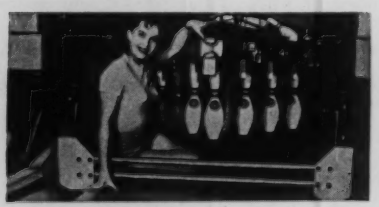
OFFERS MORE TUBE PER DOLLAR

Dynex, Inc., Pewaukee, Wisconsin, has switched to Republic ELECTRUNITE® Special Smooth I.D. Hydraulic Cylinder Tubing in their manufacturing operations. The switch was made because ELECTRUNITE's special smooth, micro-inch inside finish eliminated costly honing, resulting in a better end product at a lower unit cost. Typical example of how ELECTRUNITE is providing thousands of manufacturers and fabricators with "more tube per dollar."

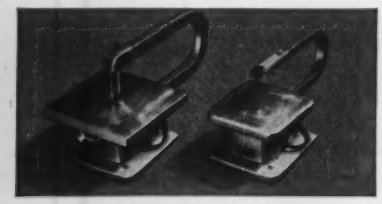
ELECTRUNITE, produced by the world's largest manufacturer of electrically welded tubing, is made from highest quality flat-rolled steel, carefully controlled through every step of manufacturing.

ELECTRUNITE Special Smooth I.D. Hydraulic Cylinder Tube is available in sizes up to 4½" O.D. in walls up to .187". ELECTRUNITE Mechanical Tubing is available in round sizes up to 6" O.D. and squares and rectangles up to periferies of 20 inches. Wide range of wall thicknesses, some up to .250" wall.

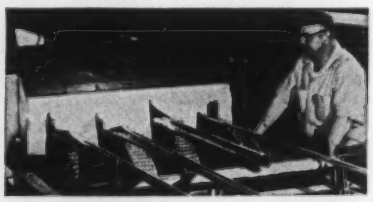
Call your Republic representative to see how ELECTRUNITE can offer you "more tube per dollar", too. Or, write direct.



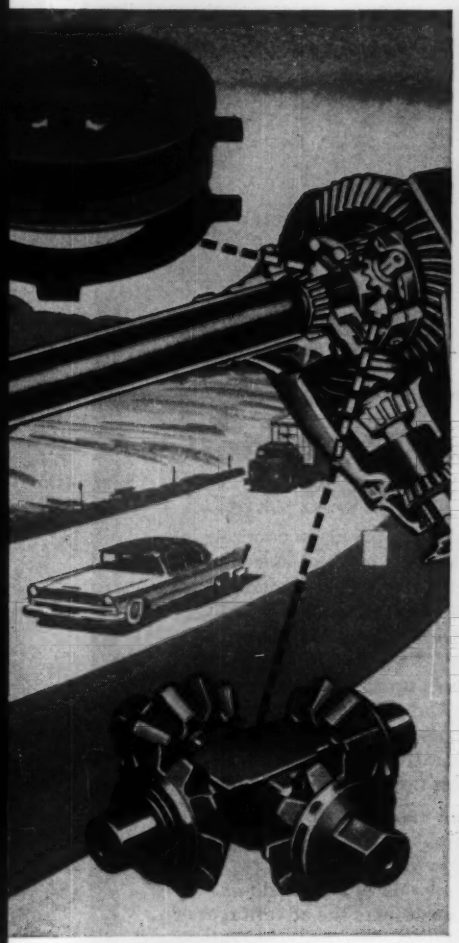
AMF CUTS COSTS, builds a better pinspotter with Republic ELECTRUNITE Mechanical Tubing. Saved $34,000 in boring, grinding, and material costs.



SAVINGS IN TIME AND MATERIALS by Syncro Corporation, Oxford, Michigan, by using ELECTRUNITE Square and Rectangular Tubing for blade-yokes.



GET REPUBLIC ELECTRUNITE Stainless Steel Tubing in sizes from ¼" through 5" O.D. Bright annealed finish available in sizes up to 4" O.D.



REPUBLIC ALLOY STEEL provides super toughness and strength at critical points in automotive differentials. The Powr-Lok differential, developed by Dana Corporation, Toledo, Ohio, permits an automotive axle to transmit the greatest driving force to rear wheels having the better traction. Republic Alloy Steels have the high strength, toughness, shock-resistance, and abrasion-resistance needed to withstand the severe service to which differential clutch rings are subjected. Write for data. Use coupon below.

REPUBLIC ENDURO® STAINLESS STEEL provides uniform quality. Tuttle and Kift Division, Ferro Corporation, Chicago, Illinois, manufactures a large share of all assembled electric range heating elements produced. They find they can depend on Republic Stainless Steel to meet the rigorous standards they demand. They find the quality is consistent. They like Republic's excellent metallurgical and delivery services. To learn more about the advantages of stainless steel, call your Republic sales office, or send coupon.

REPUBLIC CARBON COMPATIBLE IRON POWDERS cut costs, broaden the application of powder metallurgy. Big news in powder metallurgy continues to come from Republic. As a result of project 501, Republic has developed and is producing at its Toledo, Ohio, plant, two types of carbon compatible iron powders. Designated as types MS and HS6460, these powders represent a major advancement for the powder metallurgy industry. For additional information and technical data, use the convenient coupon below.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. MD-7973
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on the following products:

☐ ELECTRUNITE Hydraulic Cylinder Tubing ☐ Line Tubing
☐ Mechanical Tubing ☐ Stainless Steel Tubing
☐ Alloy Steels ☐ Stainless Steels ☐ Iron Powders

Name_____ Title_____

Firm_____

Address_____

City_____ Zone____ State_____

Circle 432 on Page 19

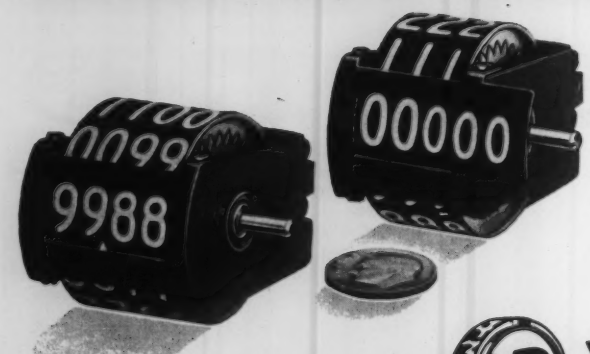
Men who Count KNOW

it pays to give their customers Veeder-Root Counting Precision

If you need ultra-precision counters to build into your product as an added service to your customers, then take a long look at Veeder-Root Instrument-type Counters, like those shown below. You'll see craftsmanship that measures up to ultra-precision standards. And you can count on it that Veeder-Root precision remains a constant quantity under highest speeds and toughest operating conditions.

Veeder-Root can bring to your counting problem the longest experience in precision counter-making of anyone in this business. Give your customers the advantages of built-in counters, give them the lifetime assurance of Veeder-Root precision.

You always "Know the score" when you count on Veeder-Root!



NEW VEEDER-ROOT MINIATURIZED COUNTERS

These Internal Pinion Counters have ⅛" wheels on which the figures are a full ¼" high, combining minimum size with maximum readability. Runs at continuous speeds of 400 rpm, and intermittent speeds of 750 rpm. Torque 1.5 oz. Meets military specifications. Originally built-in parts of navigational instrumentation, these counters are applicable to many other uses.

Everyone can Count on

Veeder-Root INC.

Hartford 2, Connecticut

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

Circle 433 on Page 19

NEW...
from Skinner!

3-way, high-flow, solenoid valves for general industrial use

Main orifice sizes: full effective—⅜", ½", ¾" for ⅜", ½", ¾" NPT.

Standard operating pressures: 5 to 150 psi.

Media: oil, air, water, vegetable and petroleum oils, inert gases, kerosene, gasoline.

Types: normally open, normally closed and directional control in standard and explosion-proof construction.

These new, 3-way L3 Series valves, like all Skinner valves, are built to UL standards. Their bodies are made of forged naval brass and their internal parts are stainless steel and brass. Soft, synthetic inserts and seals provide bubbletight sealing. And a unique, Buna-N coated nylon diaphragm assembly assures long life. The valves are compact, light, and mount in any position, directly to the line. They are offered in a wide range of voltages and frequencies, with many electrical options and manual override.

Typical applications: air vises, chemical process equipment, presses, water treatment equipment, industrial machinery, packaging machinery, air and hydraulic cylinders, laundry machinery, etc.

Skinner solenoid valves are distributed nationally.

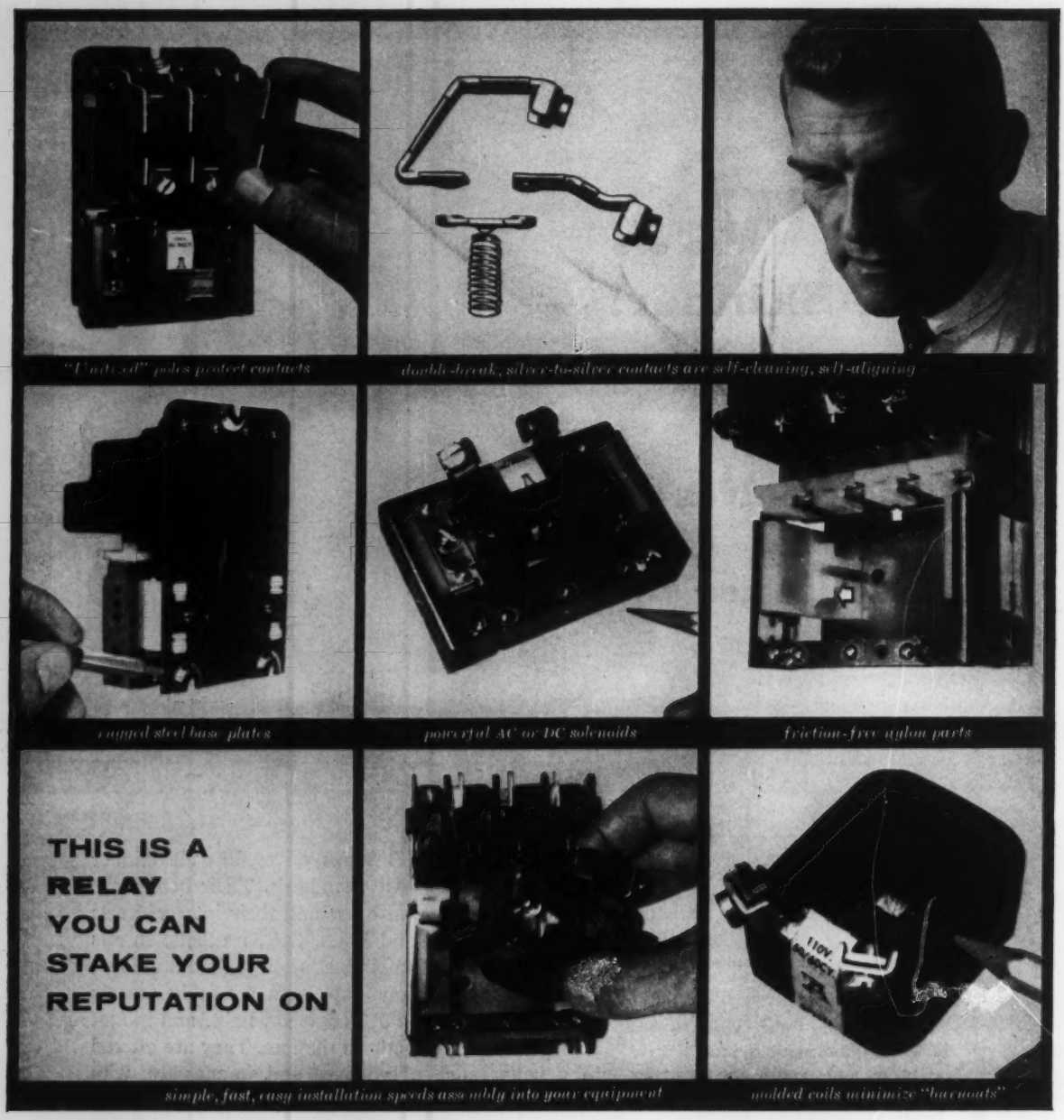
For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept. 427.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

THE SKINNER ELECTRIC VALVE DIVISION • NEW BRITAIN, CONNECTICUT

Circle 434 on Page 19



every aspect of Ward Leonard bulletin "HR" relays is designed for maximum reliability . . . these are components you can buy, install and then forget

Ward Leonard "HR" relays are engineered for industrial and electronic applications requiring: ultra-long life, high speed, high reliability, compactness and versatility.

Consider the powerful solenoids, just one of the features shown above. Every HR relay, AC or DC, is equipped with a powerful solenoid to assure fast, consistent, long-life operation so essential in the circuitry of any high reliability relay. The "E-I" laminated magnet armature is free-floating and self-aligning to minimize noise level. DC solenoids feature exceptionally fast operation. Nylon armature guides minimize operational friction. All AC and DC power plants are readily interchangeable.

2 to 8 pole "HR" relays are but one of five W/L lines of industrial power relays . . . all designed with emphasis on reliability. Write for bulletin 4470. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N.Y. P.1

WARD LEONARD
ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

LIVE BETTER...*Electrically*

Rentc-Engineered Controls Since 1892

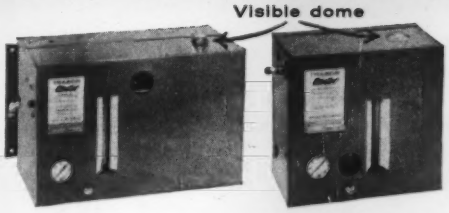
RESISTORS | RHEOSTATS | RELAYS | CONTROLS | DIMMERS

Circle 435 on Page 19

TRABON®

CENTRALIZED LUBRICATING SYSTEMS

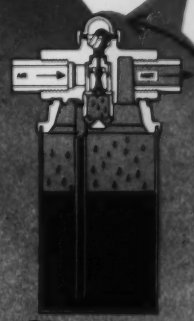
...packages with a plus!



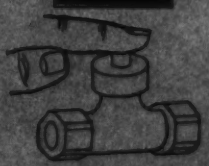
Meter-Mist units are available in 12 package sizes to fit every job.

Meter-Mist oil systems give you all these extras—at low cost

- Neat, compact lubricator units with all components housed in tamper-proof lock-cover
- Reservoir sizes up to 3 gallons—enough for 200 hours or more without refilling
- Misting-head capacities to handle up to 1000 bearing-inches without "manifolding"
- Complete visual indication of (1) oil feed, (2) air pressure and (3) reservoir level with cover closed and locked
- Pre-wired, with all wiring run to terminal strip
- Pre-piped, ready for air and outlet connections
- Remote mist indication at bearing tap
- Automatic controls and fool-proof warning signals



Visible oil feed sight provides a quick means of checking oil flow.



Finger tip pressure on pin of special flow indicator fittings located at remote bearings quickly checks mist condition at that spot.

Trabon Meter-Mist, the modern inexpensive lubricating method *for all types of bearings, slides and gears*, gives you the "extras" you want *in packaged form* when a centralized oil-fog system is indicated. Adopted by industry for machine tools, presses and even rolling mill lubrication, Meter-Mist systems transmit micron-sized particles of oil, formed at the misting-head, in the form of a dry mist to bearing areas via low pressure air. There, reclassifier fittings cause the mist to wet-out on the bearing or gear surface.

For more information about Meter-Mist and its 12 packaged models write for Meter-Mist Bulletin 658.

"*Centralized*" OIL AND GREASE SYSTEMS "*Meterflo*" CIRCULATING OIL SYSTEMS

Trabon **Trabon Engineering Corporation** 28769 Aurora Road • Solon, Ohio

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COPPER MAKES BEAUTIFUL MUSIC

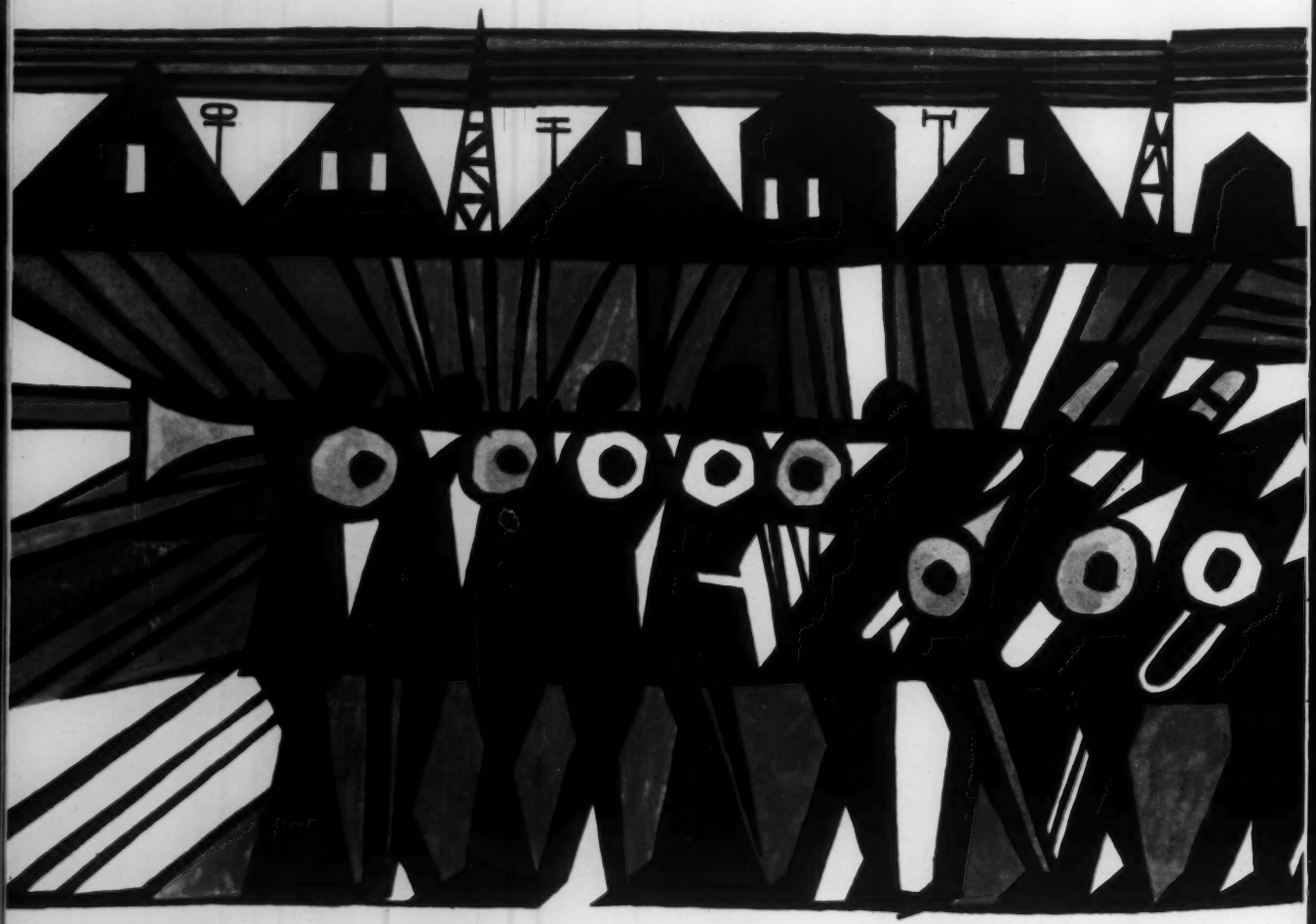
round tones, deep tones, sharp tones, flat tones.
copper makes brass, bells and bugles, trumpets and trombones.

copper makes bronze for a beethoven bust.

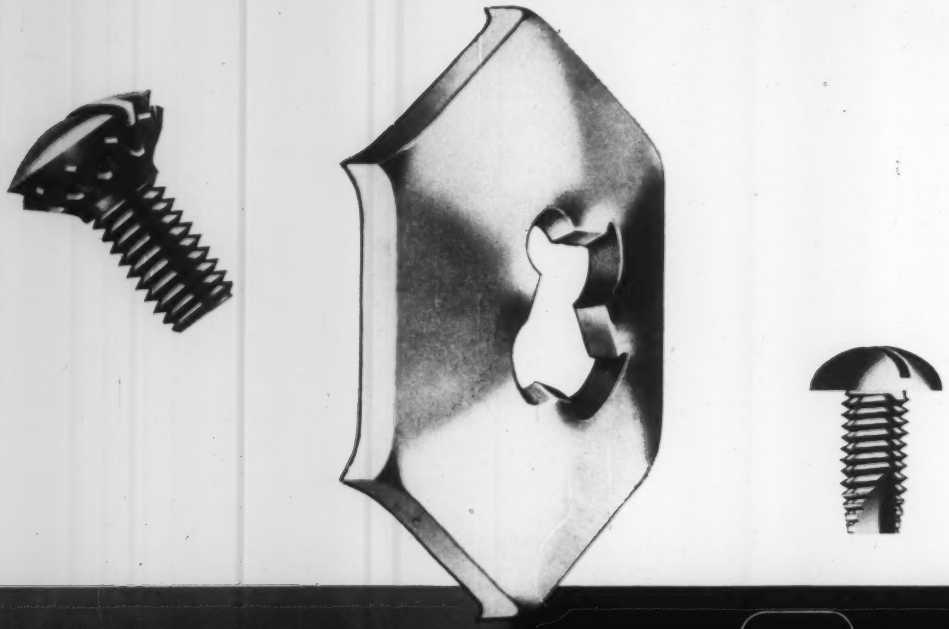
and copper makes wire. wire, wire, printed wire.
wire for radio, wire for stereo. wire for telephony and tv.

music. modern music. copper's the conductor.

without copper . . . how still the air.

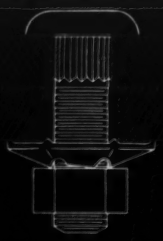


♀ For information about Copper and Copper Alloys, write Copper & Brass Research Association, 420 Lexington Avenue, New York 17, N. Y.



HOW TO SELECT COST-SAVING

fasteners for heavy duty applications



A TYPICAL EXAMPLE:
How to Fasten Securely to Avoid Shifting

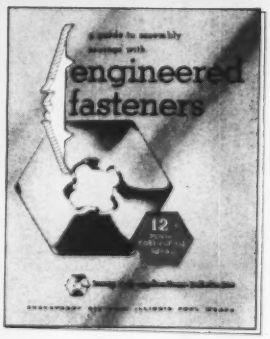
Where considerable tension in the fastening is needed to keep the parts from shifting, the Shakeproof®-developed Pyramidal Lock Washer* should be used. This washer spans large clearance holes — provides tension needed to keep parts securely fastened and in alignment.

*U.S. Pat. No. 2,794,476

For want of the right fastener, man-hours and money are often needlessly lost! It's vital to economical assembly line production to specify fasteners for each application that will do a fast and effective job *every* time. Fasteners engineered by Shakeproof assure maximum locking, reduce handling, and provide many additional functions that save assembly time, reduce production costs and improve your product's quality.

SEND FOR NEW SHAKEPROOF BULLETIN NO. 200

Shows typical examples of money-saving fasteners developed by Shakeproof engineers for heavy metal applications. Offers testing samples. Write for your free copy today!



SHAKEPROOF
"FASTENING HEADQUARTERS"®
DIVISION OF ILLINOIS TOOL WORKS
St. Charles Road, Elgin, Illinois
In Canada: SHAKEPROOF/FASTEX
Division of Canada Illinois Tools Limited, 67 Scarsdale Road, Don Mills, Ontario

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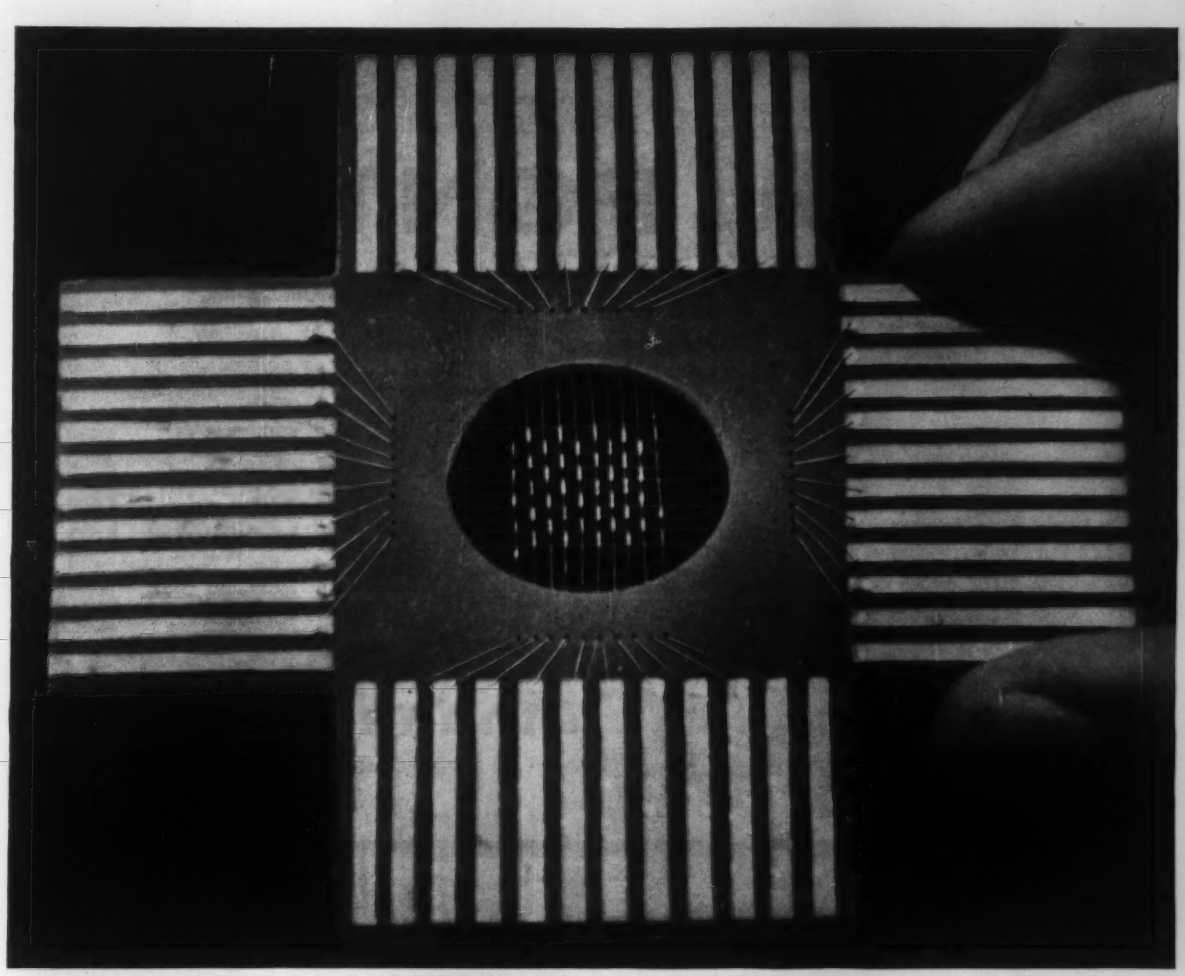


New twist in memory devices. This simplified model illustrates the basic structure of the "Twistor" magnetic memory. Developed by Bell Telephone Laboratories, the Twistor depends on unique magnetic properties of high-nickel alloy wire.

They twist high-nickel wire to make a machine remember

A new child's toy? Hardly.

This tiny part is an ingenious new kind of magnetic memory. It may well be the heart of the computer of the future.

They call it the "Twistor." It takes advantage of the unusual magnetic behavior of a twisted high-nickel alloy wire.

A group of these wires, interwoven with other wires to form a screen-like grid, can store thousands of "bits" of information magnetically, ready to answer the call of the computer.

The result is a magnetic memory device that costs and weighs less, yet is more compact and rugged than conventional devices.

What makes the Twistor practical is a unique magnetic property found in the high-nickel alloy used for the wire: when twisted, its preferred direction of magnetization shifts from a longitudinal to a helical path. In addition, this alloy permits operation with very low currents so its minute energy requirements are easily supplied by transistor circuits. And, of course, since the alloy is mainly Nickel, corrosion is no problem.

For new twists in design – or in solving metal problems, – Nickel or one of its alloys may offer what you are looking for. If corrosion, wear, high or low temperatures, stresses or fatigue are factors, let's get together to talk it over.

The International Nickel Company, Inc.
67 Wall Street New York 5, N.Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

DU PONT ANNOUNCES

ADIPRENE® L

a new liquid urethane rubber

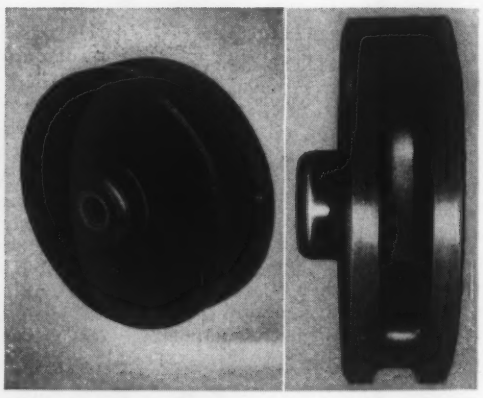
Hardness, Shore A	88	95	97	99+
Hardness, Shore D	43	48	60	78
Modulus, 300%, psi	2100	3200	7000	—
Tensile Strength at Break, psi	7000†	8825†	8500†	8500†
Elongation at Break, %	450	480	340	250
Split Tear, ASTM-D 470 lbs./linear inch	50	155	160	200
Compression/Deflection, psi @ 5% defl.	275	375	650	1400
Rebound Resilience, %	45	40	42	45
Oil Resistance	Excellent	Excellent	Excellent	Excellent
Low Temperature Brittle Point, °F.	<-80	<-80	<-80	<-80

PROPERTIES OF CURED ADIPRENE L POLYMERS

(High Hardness Compounds*)

*Softer compounds ranging from 10 Shore A are also available.

†Samples pulled @ 1"/minute (elastomer stocks normally pulled at 40"/min.)



ABRASION — ADIPRENE pump impellers, like this one, have handled 380,000 tons of solids in the form of an abrasive acid slurry without need for replacement. Normal life expectancy for impellers made of other materials is 170,000 tons of solids.

ADIPRENE L is an improved urethane rubber researched and developed by the Elastomer Chemicals Department of Du Pont. It offers the designer a new material that combines the resilience of rubber with the hardness and load-carrying capacity once found only in metals and hard plastics.

In its raw state, ADIPRENE L is liquid in form. Cured polymers can be made in varying hardnesses—from 10 to 99 Shore A (78 Shore D). These vulcanizates are outstanding in abrasion resistance, low temperature performance, and oil resistance. They resist the attack of oxygen, ozone, radiation, many chemicals and solvents.

You will want to evaluate this new synthetic rubber in improving the products you design. The performance data presented below will suggest areas where ADIPRENE L might be useful to you. More complete information is contained in our new booklet. Send the coupon today for your copy. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-7, Wilmington 98, Del.

SEND FOR MORE INFORMATION

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-7
Wilmington 98, Delaware

☐ Please send me your new booklet on ADIPRENE L, outlining the properties and design possibilities of this new Du Pont elastomer.

☐ I am particularly interested in the application of ADIPRENE L to the following product:

_____

Name _____

Firm _____

Title _____

Address _____

City _____ *Zone* _____ *State* _____

DU PONT
REG. U. S. PAT. OFF.

SYNTHETIC RUBBER

NEOPRENE
HYPALON®
VITON®
ADIPRENE®

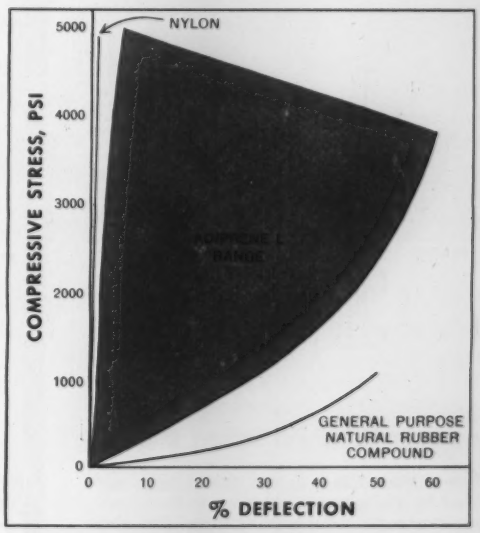
Better Things for Better Living . . . *through Chemistry*

AN OUTSTANDING COMBINATION OF HARDNESS, RESILIENCE AND LOAD BEARING CAPACITY—ADIPRENE L polymers combine high hardness with elasticity. As a result, you might use them to replace metal or similar non-elastomeric materials in applications where cushioning or damping properties would improve performance or wear. Industrial rolls, ball joint liners, motor mounts, sleeves and bushings, striker plates, and sealing devices are just a few of the possibilities.

OUTSTANDING AT SUB-ZERO TEMPERATURES—ADIPRENE L vulcanizates do not become brittle at temperatures as low as –80° F. and exhibit outstanding resistance to thermal shock.

OUTSTANDING ABRASION RESISTANCE—Both in the laboratory and in actual service, ADIPRENE L has demonstrated its ability to resist wear. On caster wheels for fork lift trucks, as an example, tires made of ADIPRENE give 8 to 10 times the performance of conventional rubber and plastic tires.

OTHER PROPERTIES—ADIPRENE L also resists the action of lubricating oils, greases, and automotive fuels. It can be used where salt solutions or dilute mineral acids and bases are encountered at room temperature. ADIPRENE L shows good resistance to oxygen, ozone and radiation, and will perform for long periods at 212° F. (up to 250° F. for shorter periods).



LOAD BEARING CAPACITY of hard ADIPRENE L compounds (shaded area of curve) ranges between that of general-purpose rubber and the harder plastics.

how to pick

the one right SOLID PIN for the job

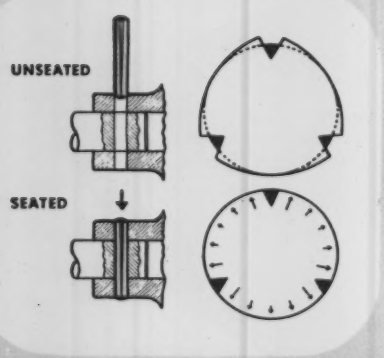
(the solid Groov-Pin is still the safest, surest way to pin two parts together)

The Groov-Pin has the holding power of a press fit pin *without* the need for close tolerances, and the ease of installation of a taper pin *without* the need for reaming.

You just drill the hole and drive the pin home. Once seated it stays there . . . no matter what the condition of shock or vibration.

Available in low carbon steel or other materials (stainless pins are Type 303, nonmagnetic). Diameters from 1/32" to 1/2" are standard; larger sizes are special – but priced as standard in lots above 5000.

Write today for samples, comprehensive catalog, and acetate copy of this ad suitable for wall mounting. Groov-Pin Corporation, 1130 Hendricks Causeway, Ridgefield, N. J.



the unique GROOV-PIN locking principle

When a Groov-Pin is driven, the material displaced by the grooves is forced to flow back, setting up a powerful locking force. The ability of Groov-Pin to hold under severe shock and vibration . . . and its immunity to vibration fatigue . . . has been thoroughly proved by the billions in use!

GROOV-PIN

Circle 441 on Page 19

fastening gears, pulleys, sprockets, collars and cams to shafts.

type 1

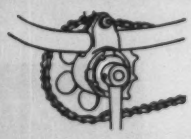
The basic Groov-Pin and most widely used. Has three full length grooves tapering from maximum diameter at one end to nominal diameter at the other.

locating pins, stop pins, hinge pins.

type 2

Grooves cover only one half of pin length. Used where holding power is not critical. Speeds assembly because ungrooved portion acts as a pilot.

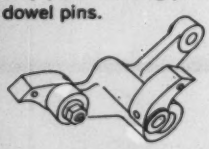
clutch and brake pedals to cross shaft; bike pedal arms to brake shafts.



type 3

Recommended for severe shock and vibration applications, its full length parallel grooves give it great holding power. Type 3H is essentially the same, but has pilots on both ends suiting it for hopper feeds.

stop pins, locating pins, dowel pins.



type 4

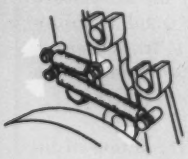
Similar to Type Two, but taper on grooves is reversed, meaning groove end is inserted first. This is particularly good on blind hole applications.

aircraft cowling, cover plates for buses, trucks.

type 5

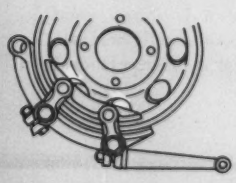
Has three oval grooves half the length of the pin, centrally located. Especially suited for quick removal and replacement. Type Five is also well suited for hinge pin applications.

spring anchors, spring control pins.



type 6

Same as Type Two, but with annular grooves on ungrooved end for spring anchor or retaining ring. Type Six is for through holes; Type Seven for blind holes. In addition, annular grooves may be machined to your specification – for use with retainer rings, for example. See catalog for standards.



type 7

EC-1357 cuts costs, makes possible stronger sandwich panels

LABORATORY TESTS show EC-1357 provides the high strength and rigidity called for in nonload-bearing sandwich structures.

3M Adhesive EC-1357 bonds all kinds of skin and core materials *without heat.* You'll speed production, cut costs, build in high strength for non-load-bearing sandwich panels.

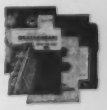
You can force-dry the solvent out of the adhesive prior to bonding. And a nip roller or cold press is all that is required to complete the bond.

EC-1357 provides maximum immediate strength. And the bond continues to strengthen as it cures at room temperatures.

Dark in color, EC-1357 absorbs infrared heat quickly, dries fast; so no production delay is necessary. And it sprays on with minimum cobwebbing, thus saving materials.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

Consult 3M Research. Contact your 3M Field Engineer. Or, for information and free literature, write: A.C.&S. Division, 3M, Dept. YQ-79, St. Paul 6, Minnesota.



ADHESIVES, COATINGS AND SEALERS DIVISION

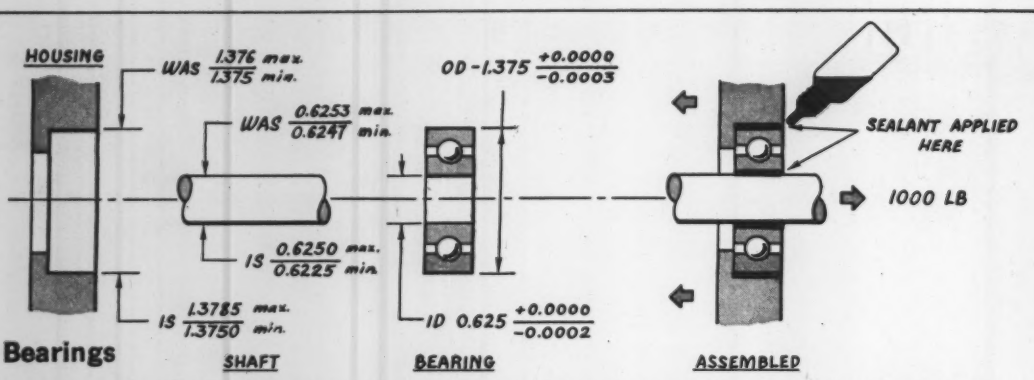
MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

SIMPLIFY ASSEMBLY...
Retain parts on shafts with slip fit and Loctite

Designing with liquid LOCTITE eliminates press fits, shrink fits, broaching, knurling, keyways, set screws and pinning . . . provides easier tolerances . . . cuts rejects and rework.

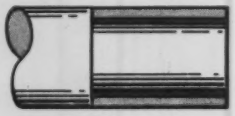


Bearings

LOCTITE Sealant replaced press fit, opening up tolerances .002 inch on shaft and housing. Rejects were cut from 8% to 1% and rework from 20% to 0! Bond to inner race withstands 1000 lbs. thrust . . . equal to the best press fit. Slip fit with LOCTITE gives more uniform retention . . . eliminates fretting damage due to loose "press fit" or bearing distortion resulting from tight press fit . . . assures better shaft alignment. Easier tolerances speed assembly.

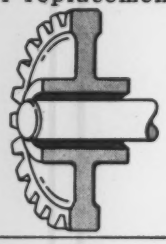
Hardened Sleeves

Eliminates shrink fit . . . mounts hardened sleeve without pulling temper.



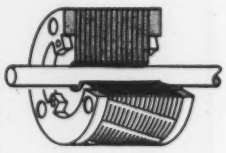
Gears and Pulleys

Eliminates broaching, knurling, shaft distortion. Easier gear replacement.



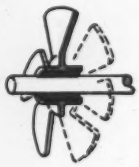
Rotors

Eliminates shaft distortion and resulting regrinding & straightening.



Fans

Eliminates set screws . . . no amount of vibration will loosen part.



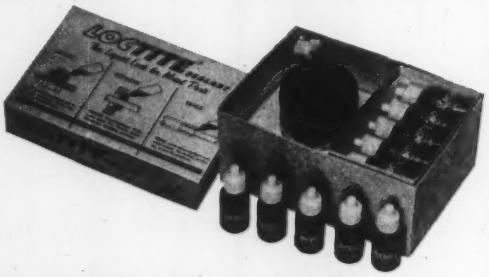
LOCTITE Sealant is easy to apply . . . simple to automate

LOCTITE is a one-component liquid with the unique property of converting to a tough plastic when confined between close fitting metal parts. It does not air dry. It does not require mixing with a catalyst and will not spoil on standing in a storage vessel. It comes fully prepared . . . stores for years . . . hardens only when treated parts are assembled. It forms a tough seal that resists heat, oil, water, all common solvents. Parts treated with LOCTITE can be disassembled by ordinary methods.

LOCTITE Kit No. 10-10

Contains 10 grades of Loctite Sealant specially put up to assist designers in determining proper grade and use of Loctite in product development and for general experimental work. By selection of proper grade, the designer can apply a predetermined amount of locking torque.

Write for literature and free sample.



LOCTITE® SEALANT AMERICAN SEALANTS CO. 111 Woodbine St., Hartford 6, Conn.

FAWICK Type ER Clutch installed on main drive of Milnor Automatic Washer-Extractor.

Fawick Clutches here...

mean fast, accurate cycling HERE!

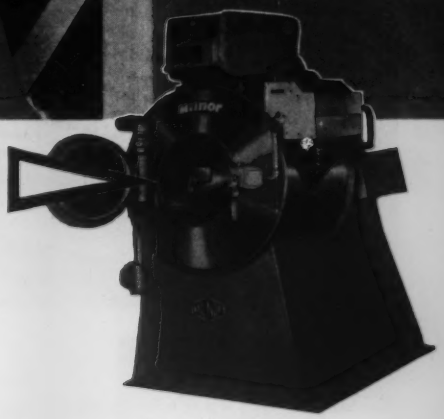
Both manufacturers and users of commercial automatic laundry washers know that their success depends on fast, accurate cycling of their equipment.

That is one major reason why the Pellerin-Milnor Corporation, New Orleans, La., uses FAWICK Clutches on the main drives of their famous Milnor Automatic Combination Washer-Extractors.

The FAWICK ER Clutches on these machines respond instantly to programmed controls, supply full torque to the work load—with continuous "new clutch" performance over a long, maintenance-free life.

This is but one of hundreds of installations on a wide variety of mechanical products where FAWICK provides the best answer to power transmission requirements.

For full details on the advantages FAWICK can bring to the operation of your equipment call or write your nearest FAWICK representative or the Home Office, Cleveland, Ohio.



Milnor Automatic Washer-Extractor which automatically cycles washing, rinsing, and damp drying laundry operations.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK AIRFLEX

INDUSTRIAL CLUTCHES AND BRAKES

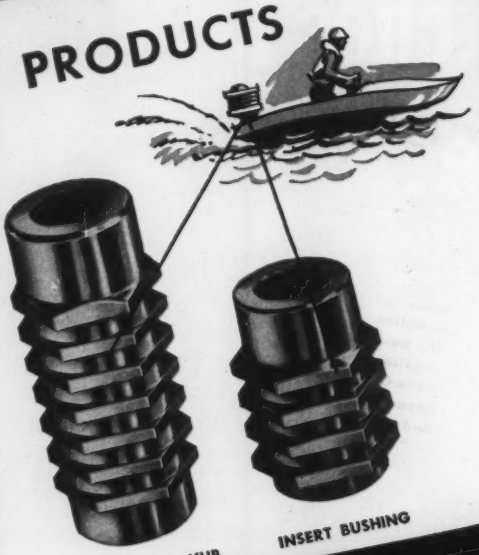
Circle 444 on Page 19

two typical cases where MUELLER BRASS *determined the best and most*

CASE HISTORY 1750

SCREW MACHINE PRODUCTS for outboard motors

Mueller Brass Co. Methods Analysis Engineers, after careful consideration of every aspect of the job requirements, found that the best method of producing these 2 outboard motor parts at the lowest cost was as screw machine products made from hollow hex rod. The insert drive hub and insert bushing are used in the lower units of one of America's most powerful outboards and must absorb constant punishment without failing. Mueller Brass Co. has one of the world's largest automatic screw machine departments fabricating both ferrous and non-ferrous custom parts. Parts can be produced in an infinite variety of shapes and sizes from ⅛" to 3¼" in a wide range of free cutting and specialized alloys. Complete facilities are available for all secondary and finishing operations, as well.



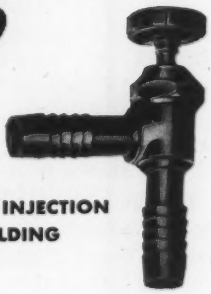
INSERT DRIVE HUB

INSERT BUSHING

THE MAN FROM MUELLER BRASS CO.

can give you sound, unbiased advice on the one best method of making your parts because Mueller Brass Co. is the only fabricator in the country offering all these methods of production. An experienced "Methods Analysis Department" has at its command a complete knowledge of the advantages and limitations of each production process. This unique technical service is your assurance of getting the best product at the best price . . . made the one best way.

FORGINGS



PLASTIC INJECTION MOLDING

MUELLER BRASS CO.

CO. METHODS · ANALYSIS · SERVICE

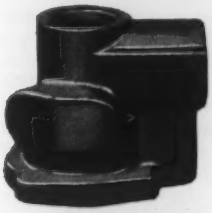
economical method of producing parts

CASE HISTORY 226

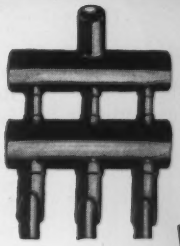
COLD-PREST® IMPACT EXTRUSION for door closer cylinder

By producing this door closer cylinder as a Cold-Prest Impact Extrusion, several important advantages are realized: formerly made in three pieces, the part is now made as one piece in one operation which eliminates machining and assembly operations. The possibility of leakage is eliminated and the part has better physical properties, as well as a smooth, bright finish. Mueller Brass Co. has complete facilities for producing Cold-Prest impact extrusions of aluminum, copper, brass, bronze and steel. Square, rectangular and cylindrical shells up to 28" in length are possible depending on wall thickness and other design details. Parts can be designed having ribs, flutes, splines or bosses . . . with multiple wall diameters and with various wall sections.

POWDERED METAL PARTS



SAND CASTINGS



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Write today for engineering manuals covering all these production processes.

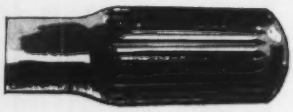
PORT HURON 20, MICHIGAN

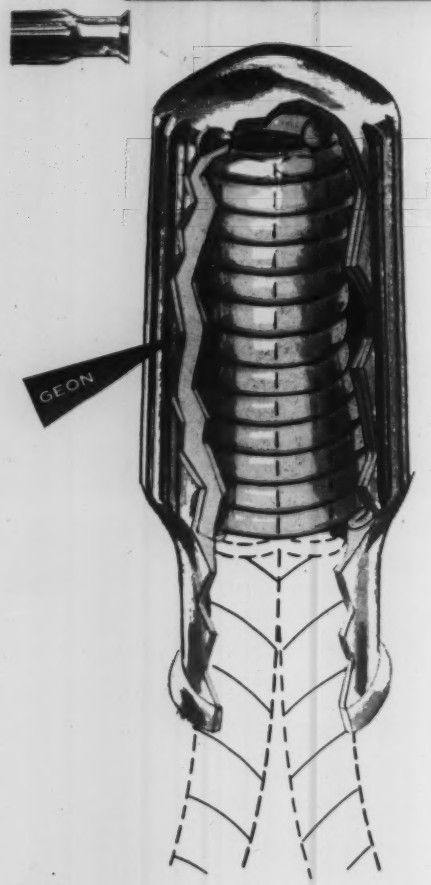
270

Another new development using

B.F.Goodrich Chemical *raw materials*

"Scotchlok" Brand electrical spring connectors, designed to give tons of holding pressure in a fraction of an ounce, are made by Minnesota Mining And Manufacturing Company, St. Paul, Minn., using caps molded of Geon by Minnesota Plastics Corporation, St. Paul. B.F.Goodrich Chemical Company supplies the Geon polyvinyl material.





High holding splices with a twist...

NEW CONNECTORS ARE CAPPED WITH GEON

Just three color coded sizes of this "Scotchlok" Brand electrical wire connector can splice over 400 wire combinations from 6 to 18 AWG solid and stranded. It consists of a bell-shaped steel spring in a hard steel shell, all fitted into a cap molded from Geon polyvinyl material.

Geon makes a tough and flexible cap. It has a long, conforming skirt to prevent flashover. And since Geon can be precision-molded, there is a knurled surface to provide finger grip, making it easier to twist the connector onto wire ends. Geon can also be molded in colors—each of the different sizes has its own color code.

Geon also provides ideal electrical characteristics. And it offers good resistance to abrasion, weathering, and heat, as well as non-flammability and low-temperature flexibility. In addition, Geon is inert to oil, chemicals and solvents.

The new U.L.-approved connector is providing permanent high-pressure splices for fixture and appliance applications, as well as for larger size wire in homes and industry. It's an example of the way that Geon makes possible new products, or new applications of existing ones. For more information, write Dept. AS-3, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

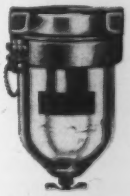
B.F.Goodrich

GEON polyvinyl materials • HYCAR rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

Reduce Costly Wear on Air Equipment

Pipe scale, pipe dope, condensate, emulsified and deteriorated compressor oil — all damaging to connected air equipment — are inherently present in all compressed air systems. Provide for the efficient removal of these contaminants and assure top performance from air actuated devices by specifying a Norgren Air Line Filter in your design.

- **99 Models to choose from** — ⅛", ¼", ⅜", ½", ¾", 1", 1¼", 1½" pipe sizes.
- **Choice of 4 Filter Elements** — 74, 64 or 25 micron... 5 micron available in some sizes.
- **Transparent or Metal Bowls**
- **Wide Operating Pressure Range** — Top efficiency at pressures as low as 5 psi—as high as 250 psi for metal bowl type.
- **Wide Operating Temperature Range**—Metal bowl models extend temperature range to 200° F.
- **Automatic or Manual Drain** — Automatic drain eliminates maintenance cost for draining manually.
- **Abrasive Solids and Corrosive Liquids** — are removed from air lines, reducing equipment wear, repair and replacement costs.



Norgren Manual Drain Air Line Filter (Norgren Automatic-Drain Air Line Filter is illustrated above.)

For complete information, call your nearby Norgren Representative listed in your telephone directory—or WRITE FOR DESCRIPTIVE LITERATURE.

If it's Norgren...It's Dependable.

C. A. NORGREN CO.

3442 SO. ELATI STREET • ENGLEWOOD, COLORADO

Circle 447 on Page 19

FOR THE ENGINEER

who can't sleep nights

If you're losing sleep over a sticky problem in automatic control, AE can help—because AE has a reputation for making things *work* automatically.

It's not surprising, considering our unique experience in the design of circuits and components for automatic telephone exchanges.

What's more, AE relays and stepping switches are unique in their own right—because they're built to have substantially zero variation in operating characteristics *for life.*

As an example: the AE Class B Relay, illustrated, provides hundreds of millions of operations with unfailing contact reliability, and seldom needs maintenance. For this reason, it is probably the most inexpensive relay you can use where infallibility is an essential.

AE relays and stepping switches are custom-made to *your* specifications – and are also available wired and assembled into complete control units. And we're always glad to suggest specialized circuits that may cut your end costs.

Want more information? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

Also yours for the asking: Circular 1702-E, *Relays for Industry,* and a new 32-page booklet on *Basic Circuits.*

AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

Circle 448 on Page 19

EXPERIENCE

builds a line of HYDRAULIC PRODUCTS

Take another look at the pumps pictured above. They're samples of an important, improved, top-quality line: *HP. Hydraulic Products Division* of Clark Equipment Company.

Behind this line is the know-how of five 20-year veterans of the hydraulic business . . . and the backing of a company old in industrial experience and known throughout the world for dependable, high-quality products.

Hydraulic Products pumps, motors, and valves are planned, in light of all this experience, to eliminate your most serious hydraulic component problems. *Quality* and *dependability* are probably the most important gains . . . HP products are built in a plant with all new tooling and the latest in automatic 100% testing. HP products are aluminum . . . compact and light in weight. Every HP product is designed for easy servicing . . . you can, for example, reseal or even rebuild an HP pump in the field without loss of efficiency.

Visit our plant. Write for our catalog or, better still, for immediate information pick up the phone and call us—Benton Harbor WAlnut 6-2133.

hp CLARK EQUIPMENT

HYDRAULIC PRODUCTS DIVISION
CLARK EQUIPMENT COMPANY
Miller Street Plant
Benton Harbor, Michigan

Circle 449 on Page 19

ONLY RAMCO MAKES BOTH TYPES OF MODERN RETAINING RINGS

TO SOLVE ALL EYE APPEAL PROBLEMS

SpirOlox

A time-tested Ramco design; full-circle 360 degree retaining ring opens up unlimited possibilities for improved design and economies in thousands of new or present products.

- √ Uniform wall allows installation with minimum clearance.
- √ Two turn, full-circle design eliminates gaps.
- √ No special tools needed for installation or removal.
- √ No tooling needed for prototypes—complete design flexibility.
- √ Develops a unique "friction lock" under load.
- √ Always uniform in quality.
- √ Special designs for high speeds or tolerance stack-up problems.

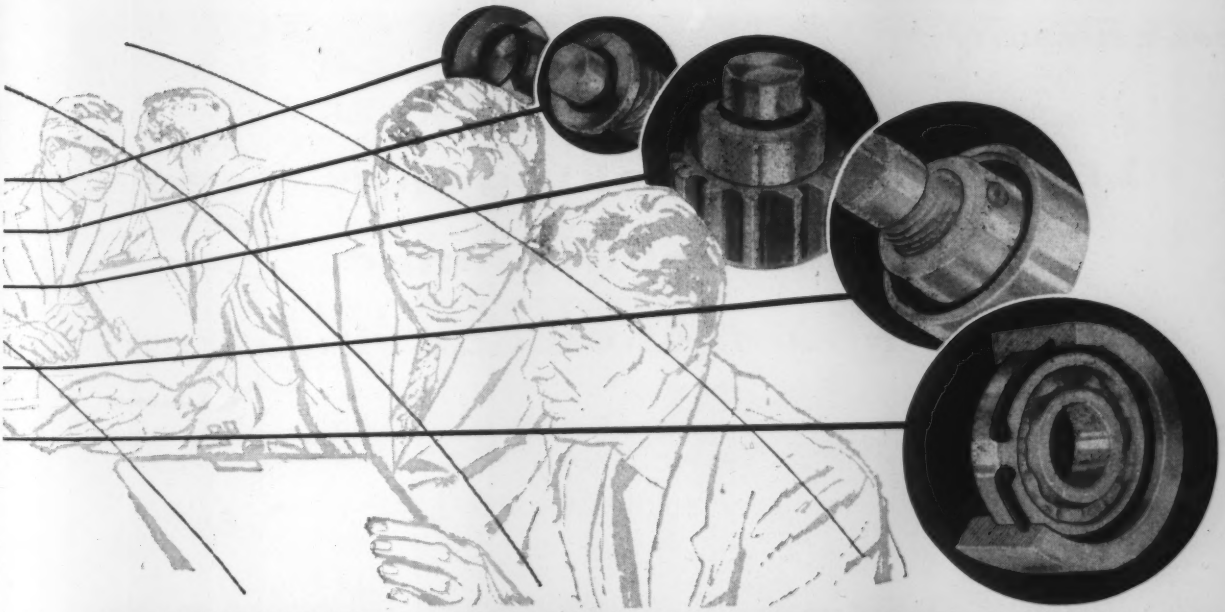
CircOlox

The answer to easy, lightweight, low cost assemblies and reduced manufacturing costs. Made in a variety of types and sizes for the smaller shaft or housing diameters.

- √ "Deep-groove" design permits maximum thrust with minimum weight.
- √ Easily installed or removed.
- √ Available in a variety of materials.
- √ Wide choice of finishes.
- √ Always uniform in quality.
- √ Meets Government and Industry Standards.

Retaining Rings by THOMPSON PRODUCTS

another product of ***Thompson Ramo Wooldridge Inc.***



APPEARANCE? ASSEMBLED COST? PERFORMANCE?

WHAT IS YOUR MAJOR FASTENER PROBLEM?

If it is appearance, Ramco retaining rings can give you the one best answer!

Who thinks of eye-appeal in retaining rings? For one, your customers do... for another, Ramco does! Eye-appeal is one reason Ramco offers both types of modern retaining rings in a wide range of designs, styles, metals and finishes.

For example, take the unique full-circle Spirolox... it can be furnished in bright stainless steel, blued steel, copper or gold plate... it can be used to improve the appearance of electric mixers, power tools and any product with an exposed retainer. No other retaining ring will give the sleek, modern, eye-appealing appearance. That's why we say, "Ramco has the one best answer."

But Ramco has the answers to your other retaining ring problems, too! Ramco can show you how to cut assembled cost and improve product performance with rings manufactured in the world's most modern ring plant... engineered to the highest standards established by Thompson Products and Ramco Engineering. Send us a blue print of your toughest retaining ring problem... let us give you the ONE best answer.

A special Engineering Catalog and Price Lists are yours without cost or obligation. Why not mail the coupon for your free copies TODAY?

RAMCO DIVISION

automotive group

TRW

Thompson Products Ramco Division
Box 513, Dept. B, St. Louis 66, Mo.
Send latest Engineering and Price Catalogs of Spirolox and Circolox Retaining Rings.

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Company.....

Address.....

City.....Zone.....State.....

Samples Wanted: Spirolox ☐ Circolox ☐ Size.....

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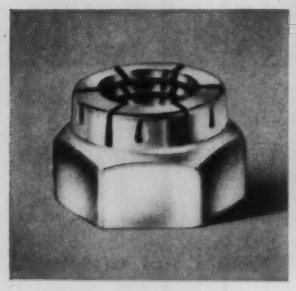
SPS RELIABILITY / *A dynamic standard of predictable performance*

FLEXLOC self-locking nuts keep your assemblies intact, despite impact, shock or vibration

Stroboscopic photo shows action of transfer mechanism on a cold-forging machine operating at approximately 16 cycles a minute. The numerous FLEXLOC locknuts used to fasten this assembly stay put despite constant shock and vibration, eliminate the nuisance of frequent retightening.



FLEXLOC self-locking nuts help solve the problem of keeping threaded fasteners tight. Repeated shock, high-speed oscillation, heavy pounding will not shake them loose. They help give your products greater reliability, a qualification that is no longer just a talking point, but a major competitive advantage.

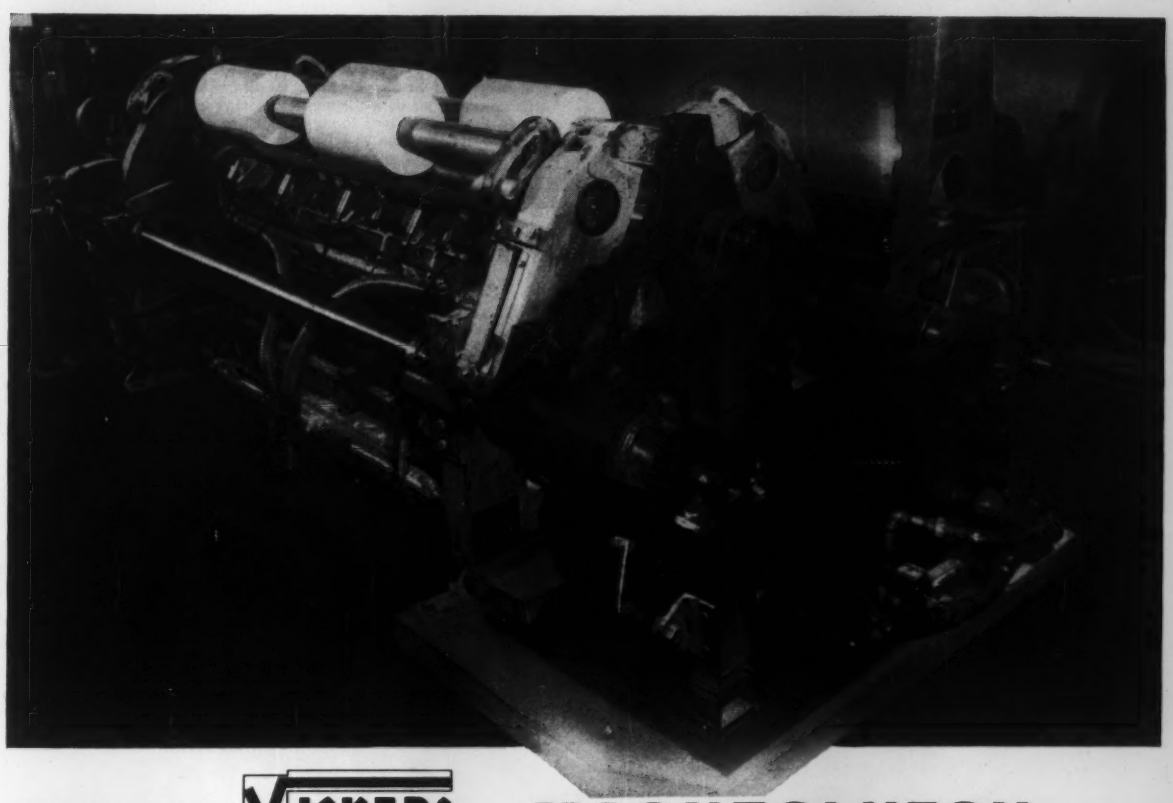
FLEXLOCs are 1-piece, self-locking fasteners requiring no lockwashers, jam nuts, cotter pins or wiring. There is nothing extra to put together, come apart or get lost . . . and no nonmetallic inserts to deteriorate, be chewed up by rough bolt threads, or weaken the structure of the nut. With a FLEXLOC, every thread, including those in the locking section, carries its full share of the tensile load.

A FLEXLOC goes on like an ordinary nut. Start it with your fingers; tighten it with a hand or speed wrench. As soon as 1½ threads are past the top, the FLEXLOC is fully locked. It serves as either a locknut or a stop nut.

Because they require no auxiliary locking devices, FLEXLOCs facilitate design and specification, simplify inventory and handling, reduce assembly time and costs. They also save on maintenance, because they are readily removed and can be reused repeatedly without impairing their locking reliability. See your authorized FLEXLOC distributor for complete information on sizes, materials and finishes. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada, Ltd. • Unbrako Socket Screw Co., Ltd.



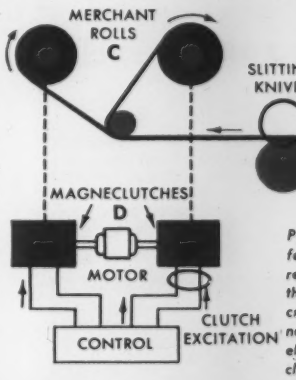
How the VICKERS® MAGNECLUTCH® CONTROLS TENSION...PREVENTS BREAKDOWN on this high-speed paper slitting machine

The smooth, trouble-free operation of this slitting machine of a well-known paper converter demonstrates another practical use of the Vickers Magneclutch, the dry magnetic particle clutch.

Two water-cooled, 200 lb-ft, 6-2-6 Magneclutches maintain uniform tension on the fast-moving web as it is unwound, slit and rewound. Strain, breaking or snarling of the paper is eliminated, downtime is prevented.

The Magneclutch is designed to provide precise regulation and transmission of torque, without grab or chatter. Torque responds quickly, is unaffected by temperature or humidity; water-cooled design dissipates slip heat rapidly; and since there is no wear on torque transmitting surfaces, service life is extremely long. Torque transmission, regulated by energizing current only, is independent of speed, and is easily and remotely controlled.

Write for Descriptive Bulletin on The Vickers Magneclutch



Paper is pulled from parent roll A, fed through slitting knives B, and rewound on merchant rolls C. As the merchant roll diameters increase, additional windup torque needed is provided by increased electrical excitation of the Magneclutches D. Clutches slip to maintain constant web speed and tension.

ELECTRIC PRODUCTS DIVISION — VICKERS

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION

EPA 6100-2

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Central Foundry

help you design better castings at lower cost

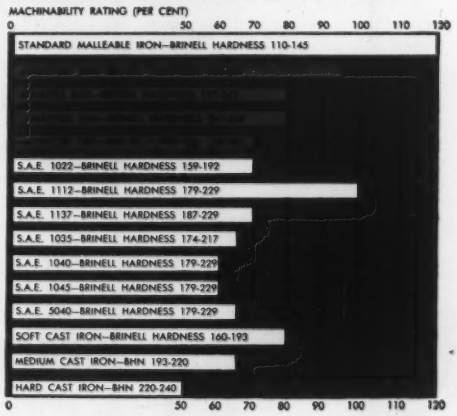
Many new developments here at Central Foundry have broadened the field of application for castings and have given design engineers greater latitude. To assist you in exploiting these new methods and materials to fullest advantage, each of our engineering departments—design, experimental, process and metallurgy—is at your disposal. Central Foundry is also using a number of testing techniques such as stress analysis, cobalt radiography and sonic testing, that have proven invaluable in lowering the cost and improving the quality of castings. These procedures help us to determine the best design and method of producing a casting, either by the green sand method or the shell mold process, and the best material for the casting, either grey iron, malleable iron or ArmaSteel.

Central Foundry has the capacity to deliver, on schedule, quality castings in production quantities.

STRESS ANALYSIS FOR IMPROVED DESIGN

An important part of our engineering services is the stress analysis laboratory. Stress analysis discovers the amount of stress on a part due to its service function and is an important aid in determining and improving the strength of a part. Improved casting design can be accomplished through the use of stress-analysis by more effectively distributing the metal in the part. The U-bolt anchor plate shown here is a case in point. Our customer was experiencing failures in this part and asked us to see what we could do to solve the problem. Using stress analysis the part was completely redesigned for maximum efficiency. The redesigned part is 35% stronger, 42% lighter and less costly.

EXCELLENT MACHINABILITY FOR INCREASED PRODUCTION



CENTRAL FOUNDRY DIVISION

REDESIGN FOR STRENGTH

This is a rear spring clip pad that was converted to a casting with the help of stress analysis. The clip pad supports the shock absorber arm and clamps the spring to the rear axle of an automobile. When produced as a stamping, this part weighed 4-1/4 pounds. However, when designed as an ArmaSteel casting, weight was reduced to 2-9/10 pounds. Most important, based on comparative stress analysis tests, the casting is *30% stronger* than the stamping. (In addition, the holes are produced by the foundry, making it unnecessary for the customer to punch them.) This conversion from a stamping to a casting resulted not only in increased strength, but in substantial cost savings, as well.

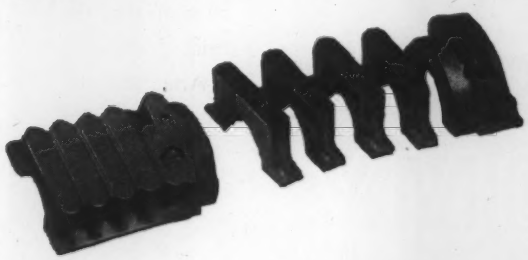
REDESIGN FOR IMPROVED PRODUCT AND ECONOMY

Many of our customers have found that redesigning a product to be made as an ArmaSteel casting rather than as a fabrication, forging or stamping, has resulted in a better part at less cost. The fabricated design of a rear wheel truck hub at the left consists of a forged base with a steel plate welded in place to form the smaller flange. The casting on the right, designed jointly by the customer and our engineers, is of single piece construction, is lighter, stronger and less costly than the fabricated design and eliminates the fitting and welding of the small flange.

FABRICATED DESIGN ARMASTEEL CASTING

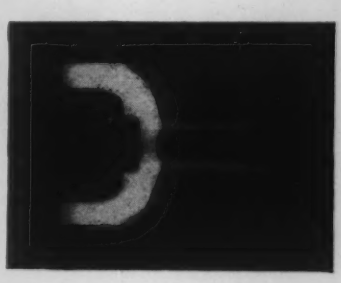
PROCESS ENGINEERING FOR LOWER COST

Our process engineers are continually looking for ways to more economically produce castings, thus lowering the finished-product cost. Shown here is a single casting that combines 5 bearing caps used on a V-8 engine. The casting is almost completely machined as a single piece, and the parts are then separated in a final operation. Substantial savings are realized in both casting and machining costs.



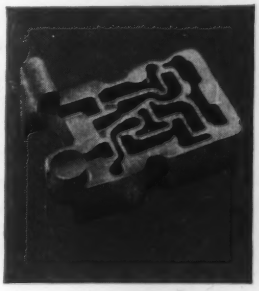
COBALT RADIOGRAPHY FOR ASSURED QUALITY

Radiography, by means of Cobalt 60, has drastically reduced the time required to check castings and is an important aid in obtaining the best possible casting quality. In an effort to eliminate a machining operation on the universal joint yoke shown here, a design change was made in the tube section of the part. When sample castings of the new design were checked radiographically, it was immediately apparent that the design was unsatisfactory since it caused acute metal feeding problems. By redesigning and further checking by radiography, Central Foundry was able to produce, in the shortest possible time, a lighter casting which required less machining in our customer's plant.



SHELL MOLDING FOR GREATER ACCURACY

Shell molding, a relatively new process of making castings, is now being employed extensively for fast, simple production of complicated castings, such as those requiring narrow, accurate passages and cross sections. It is practically impossible to produce certain parts in any other way without prohibitive costs; this is especially true of ferrous metals. Complicated parts like the manual control valve body shown here, a part of the automatic transmission of a military vehicle, are readily cast in grey iron when the shell process is utilized. The part had been considered as an aluminum die casting, but was thought unsatisfactory because of adverse expansion and wear characteristics. In this case, meeting the requirements for very close tolerances on the thickness and location of ports was made possible by the shell molding process.



REDESIGN FOR WEIGHT REDUCTION

Vehicle weight reduction is a matter of increasing importance to design engineers . . . and more and more existing parts are being converted from a low or medium to a high strength ferrous material such as ArmaSteel. On the left is a grey iron differential carrier currently used in an automobile. By taking advantage of the superior physical properties of ArmaSteel, it was possible to design the part on the right which is *five pounds lighter*. The modulus of elasticity of ArmaSteel is approximately 60% greater (the tensile strength about twice as great) than the grey iron material.

90

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

Vacuum Cleaner Manufacturer Specifies

Bending vacuum cleaner wand. A variety of fabricating operations also is performed on Ohio Special Quality Seamless Tubing.

"Value analysis showed it would be more economical to buy than produce fabricated welded tubing parts for our new cleaner. What's more, we could avoid additional capital investment in equipment.

"So we added Ohio Seamless to our production line. They have the equipment and facilities to meet our design requirements and to hold to our stepped-up schedules. And we don't pay shipping costs on scrap — just on finished parts . . ."

Let Ohio Seamless translate your designs into finished parts . . . conserve your capital . . . cut your production and shipping costs. Contact your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-8847

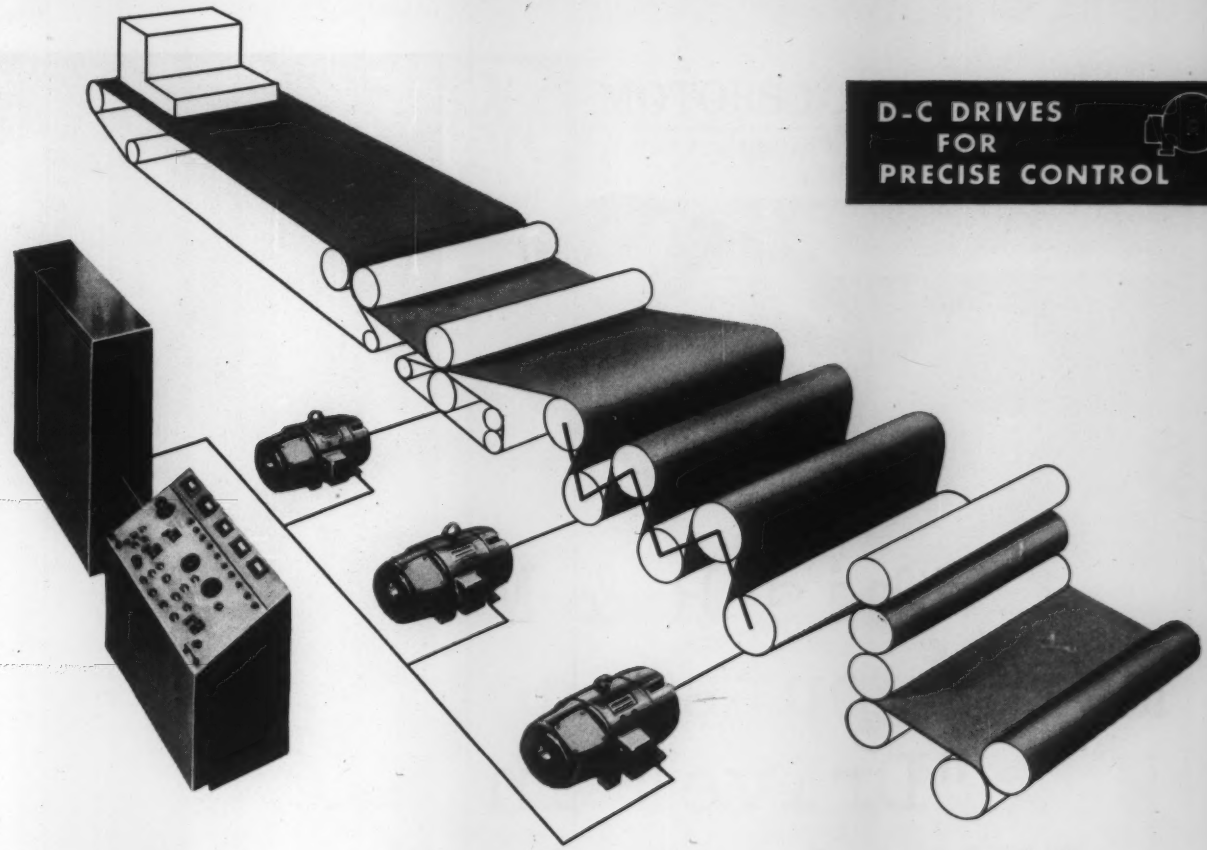
OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, St. Petersburgh, Salt Lake City, Seattle, Tulsa, Wichita CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York



Problem: How to coordinate two or more machines for greater production flexibility, lower costs

Operating at high speeds, working to close tolerances, meeting high-quality standards, today's machines must be controlled accurately. This is one of the reasons users and designers are making greater use of direct-current drives for coordinating two or more machines in multi-section process lines.

MACHINE COORDINATION IS A NATURAL JOB FOR DIRECT-CURRENT POWER. For direct current can best provide the accurate speed matching and extra measure of control needed for high-speed, automatic continuous processing.

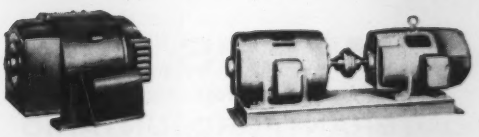
D-c's flexibility allows each individual drive motor to be run at the exact speed demanded by the section of the process it drives. Increased output, better quality control and production flexibility lower the cost per unit of production.

To learn more about the modern capabilities of direct-current power, write for your free copy of "WHY D-C?", *Section 829-3, General Electric Company, Schenectady 5, New York.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

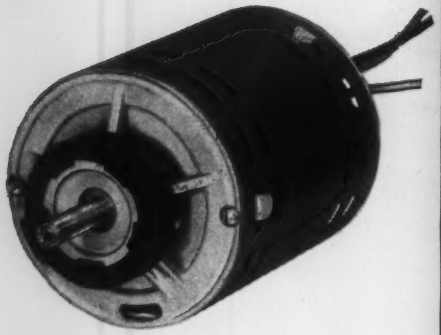
SELECT FROM GENERAL ELECTRIC'S COMPLETE LINE OF D-C DRIVES



MOTORS AND GENERATORS

POWER UNITS AND CONTROLS

Circle 455 on Page 19



this R & M motor puts the "Drive" in IBM electric typewriters!

Almost twelve years have elapsed since International Business Machines Corporation used its first R&M motor to power its electric typewriters. Since then R&M has supplied thousands upon thousands of these special motors for IBM's world-wide typewriter trade. In order to meet varying electrical conditions the world over, they are now supplied in 21 different voltages and frequencies.

IBM proposed strict requirements for powering their machine. The motor must have high starting torque for quick response . . . run very quietly . . . cooler than normal . . . fit a limited space . . . and have stamina to perform dependably year after year. Within a short period of time, R&M delivered specifications for the right design—a dynamically balanced motor that fulfilled all of IBM's standards, including reliable operation that covers thousands of hours between check-ups.

A lot of fingers have gone over the keys since R&M produced its first IBM typewriter motor, but we still subject each IBM power unit to 100% inspection. Moreover, we constantly work with IBM—and all our customers—to improve our motors and to adapt them to the ever-changing requirements of customers' products.

R&M's experience in custom-designing motors for hundreds of products, and our facilities to produce a design at low cost, are at your service. Perhaps your problem can be met with a standard *"off-the-shelf"* power unit. If so, we'll tell you . . . and recommend the right R&M motor for the job. For power by either custom or standard fractional HP motors . . . and performance that will give you a big competitive advantage . . . get in touch with Robbins & Myers today! Write for Bulletin No. 450-MD

ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

MOTORS 1/200 thru 1 HP

(other ratings up to 200 horsepower)

At left, Retractable Capstan Motor . . . shaft of this special R&M fractional HP motor rotates and also moves axially. Manufactured for IBM's 727 Magnetic Tape Unit.

At right, Standard Fractional HP Motors . . . a wide range of types, sizes and mountings for DC, single or polyphase AC; all standard voltages and frequencies.

At left, Standard Universal Motors . . . ratings from 1/50 to ½ HP. Choice of end, pad or foot mountings to permit design versatility. Custom designs also available.

At right, Series Motor Parts . . . precision-made series, universal or polyphase high-cycle motor parts. All types and sizes engineered to your requirements.

Circle 456 on Page 19

Tubing shaped to New Ideas

Many people think of tubing only in its most common form—round. As design engineers and buyers, you know it can be produced economically in a large variety of unusual shapes. But have you ever seen the particular shapes illustrated on this page? They are samples from production runs formed to extremely close tolerances to satisfy specific design requirements. End uses include Bourdon springs, surgical instruments, batons, aircraft structural parts, gun drill shanks, radar screens, door latches, electrical equipment, antennas, golf club shafts, fishing rods and bushings. However, we don't know where all the different shapes are used, or why they are required. But our ability to form them saves manufacturers in many industries considerable time and money in the fabrication of their products.

Superior regularly produces shaped tubing in many analyses of stainless steel, carbon and alloy steels, nickel and nickel alloys, and glass sealing alloys. Also in titanium and beryllium copper. Shaped tubing is generally supplied in the as-formed temper (annealed before shaping), but many special tempers can be supplied.

We can probably supply your requirements at low cost, in good time. Data Memorandum No. 17 gives full details about Superior Shaped Tubing. Write for a copy today. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

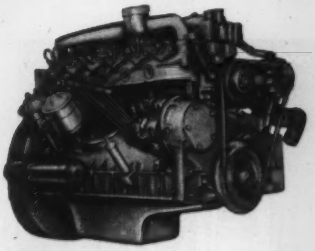
Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to 5/8 in. OD—certain analyses in light walls up to 2½ in. OD

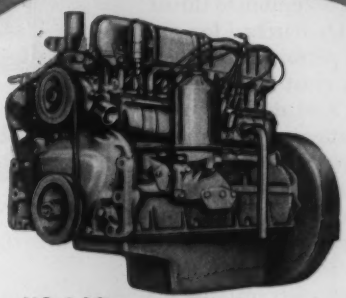
West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST



UD-236 DIESEL 75 Int. Eng. hp. Interchangeable with UC-221.

UD-282 DIESEL 95 Int. Eng. hp. Interchangeable with UC-263.

UC-221 CARBURETED 75 Max. Eng. hp. Interchangeable with UD-236.



UC-263 CARBURETED 95 Max. Eng. hp. Interchangeable with UC-282.

Diesel price barrier broken by IH 6-cyl. interchangeable engines

By making these new interchangeable 95 and 75 hp. International engines available in your products, you can switch from carbureted to lowest cost diesel power without further engineering expense, materials cost and layout and shop time. In addition, these compact 6-cylinder diesel engines offer the effective staying power found only in 4-cycle design.

Five features make these diesels standouts: 1) direct starting; 2) time-proven International pre-cup injector with single orifice nozzle for most complete combustion; 3) a glow plug in each pre-cup speeds starting by heating entire fuel-air mixture; 4) diesel injection pump is simple and dependable; and 5) an oil temperature stabilizer that increases engine efficiency.

Both the UC-263 and UC-221 carbureted engines have inherent diesel ruggedness in that each differs mainly from its interchangeable diesel counterpart in cylinder heads and pistons.

Features that contribute to smooth, efficient, economical power on gasoline, natural gas and LP Gas include: valve-in-head design; best compression ratio for each fuel; 18 mm. spark plugs; updraft carburetor and top outlet exhaust; low-friction stepped-dome pistons; and fully machined combustion chambers for uniform power from each cylinder.

Get complete details on any of these engines by writing or calling International Harvester Co., Engine Sales Department, Construction Equipment Division, Melrose Park, Illinois.

International® Construction Equipment

International Harvester Co., 180 North Michigan Avenue

A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom-Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

Circle 458 on Page 19

These standard bearings have special qualities

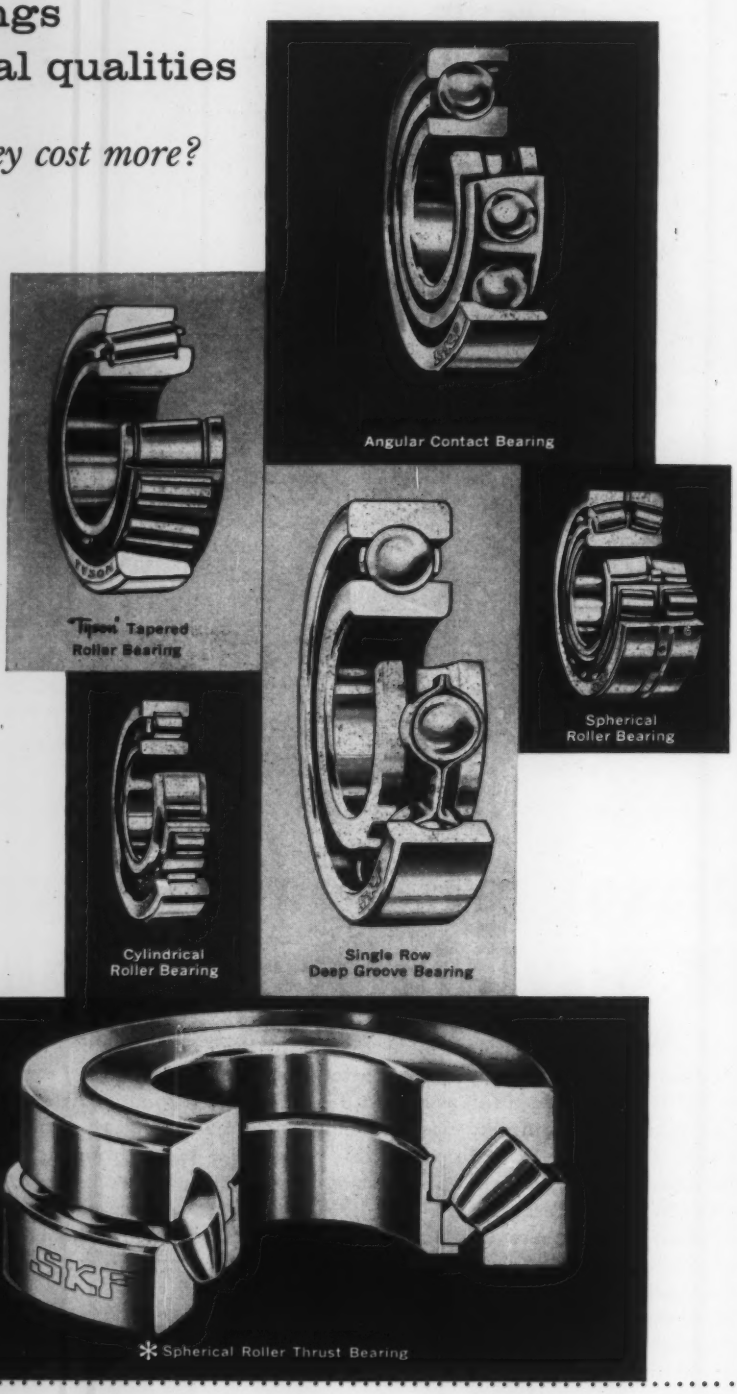
—*does this mean they cost more?*

Not necessarily.

✻Take the spherical roller thrust bearing, for example. SKF bearings of this type can carry unusually heavy loads: either thrust or combined thrust and radial. Unmatched for single bearing performance when high thrusts must be carried at high speed. And they are completely self aligning. Because of these qualities, engineers choose them for heavy-duty applications over large angular contact ball bearings.

Yet this standard SKF bearing is competitively priced. Furthermore, it is promptly available in 25 sizes ranging from 4.3″ to 14.9″ I.D.

Moderately-priced, high-quality ball and roller bearings are continually rolling off SKF's production lines. So why not get all the facts on those you can use? Just call the nearest of our twenty-five sales offices. *5927*



Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

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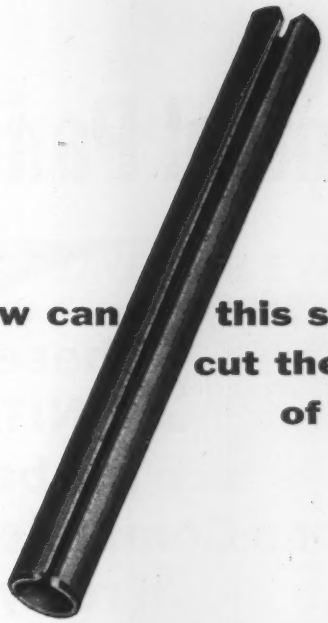
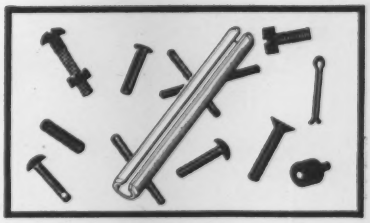


How can this simple fastener cut the cost of your product?

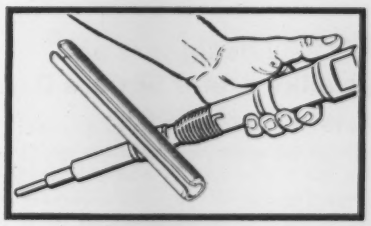
Rollpin aids standardization and reduces inventory

Rollpin readily replaces taper pins, grooved pins, straight pins and set screws; it can be used as a locating dowel, hinge pin, cotter pin, stop pin or, in some applications, even as a rivet. Thus, when you standardize on a Rollpin you can drastically reduce the variety of fasteners in your inventory—save money in purchasing, storage space and stock handling.



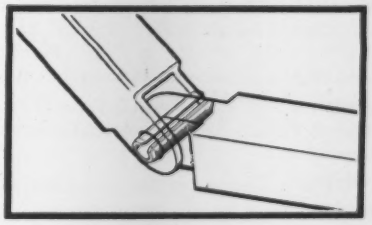
Rollpin simplifies production processing . . . saves man-hours

When you use Rollpin you can eliminate costly precision drilling, or tapping operations. And there's no need for any secondary locking operation—such as lock wiring or peening. That's because Rollpin is a slotted tubular steel spring whose chamfered ends drive easily into standard production-drilled holes, compressing as driven. The spring tension against the hole walls retains Rollpins securely against severe vibration. Independent studies have shown that installed costs of Rollpin are as much as *91% less* than those for a dowel pin or *95% less* than the installed cost of a taper pin.



Rollpin simplifies product maintenance

Only a drift pin or standard punch is required to remove a Rollpin. The slotted tubular shape and the spring action principle do not damage hole walls or enlarge the original hole diameter. Consequently the same pin is easily re-inserted and can be used again and again. Mail our coupon today for the complete Rollpin story.



ROLLPIN®

a product of

Elastic Stop Nut Corporation of America

Dept. R58,-74, Elastic Stop Nut Corporation of America
2330 Vauxhall Road
Union, New Jersey

Please send the following free fastening information

- ☐ Rollpin bulletin
- ☐ ELASTIC STOP® nut bulletin
- ☐ Here is a sketch of a fastening problem. What ESNA® fastener would you recommend?

Name_____

Title_____

Firm_____

Street_____

City_____ Zone____ State____

Smaller Control Panels with

CLASS 8501
TYPE DO-22

These 2 UNITS are the basis for a Complete System of relays

CLASS 9050
TYPE AO-1E

Here's why designers and users alike prefer Square D...

Complete selection • Relays available for both AC and DC systems—with up to 10 contacts—in both electrically and mechanically held forms. Timing relays with intervals from 0.2 second to 3.0 minutes—also in AC and DC versions.

Require less panel space • Relays are only 3" wide, range in height from 3¼" to 5". Timers are just 2⅜" x 4⅜6" or 2½" x 7²½". Mechanically held relays require no extra panel space.

No mounting problems • All Type D relays and Type A timers have identical mounting hole dimensions.

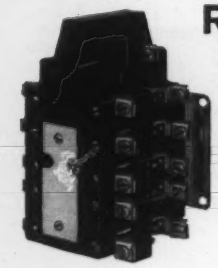
Easy wiring • Choose either pressure wire connectors or slip-on connectors for all terminals.

Long life • Balanced construction reduces wear on single moving part. Epoxy-resin molded coil operates cooler, virtually eliminates coil burnout.

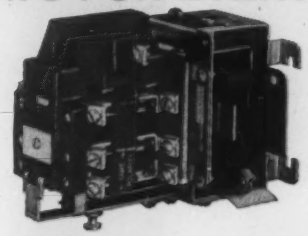
SQUARE D COMPANY

Square D "SYSTEM-DESIGNED" Relays

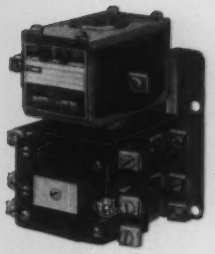
RELAYS FOR EVERY JOB



Square D Type D relays available with up to 10 contacts

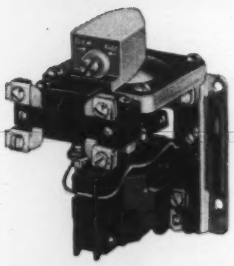


Easy-to-use attachment converts any Type D relay to mechanically hold with no increase in panel space

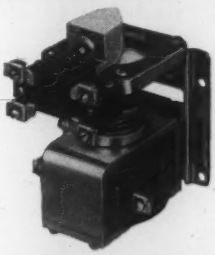


DC relays have mounting dimensions and contact arrangements identical to AC relays

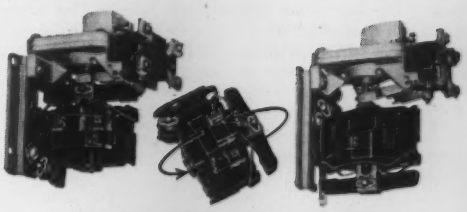
WIDE CHOICE OF TIMERS



Timing relays have same mounting dimensions as Type D relays

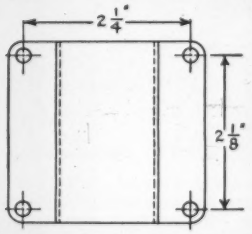


Matching DC timing relays

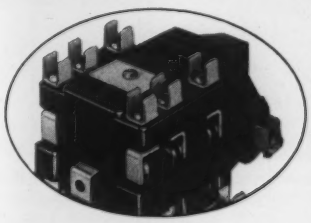


Both AC and DC versions convertible from on-delay to off-delay, using only a screwdriver

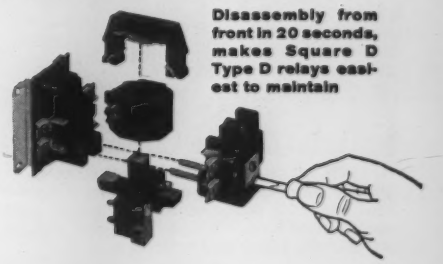
FAMILY FEATURES SIMPLIFY DESIGN PROBLEMS



Mounting dimensions are identical for Type A timers and Type D relays



Slip-on connectors for all terminals available



Disassembly from front in 20 seconds, makes Square D Type D relays easiest to maintain

Write for full details • *Ask for Bulletin D, Square D Company, 4041 N. Richards St., Milwaukee 12, Wis.*

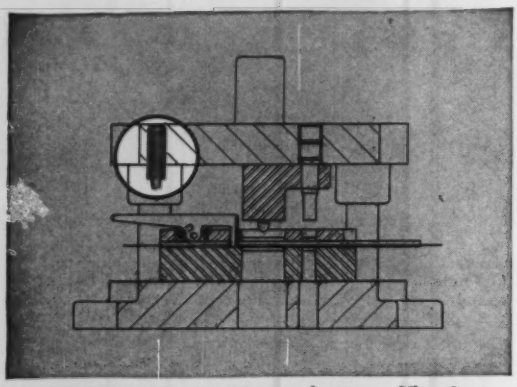
Square D offers the broadest line of relays, starters and accessories for all types of control systems

Ask your Square D Field Engineer about the new ILO program

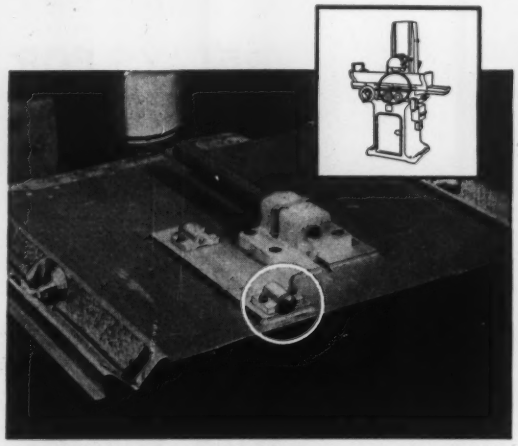
Practical Design Tips

Number 2 of a series.

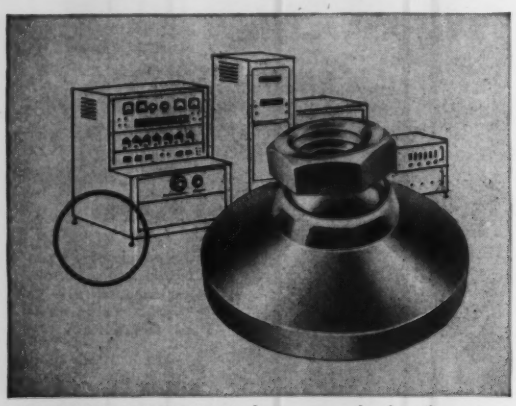
Substituting simple, off-the-shelf Vlier Tooling Accessories for complicated, custom-made devices in both tooling and original equipment applications can result in important savings. Why not put them to work in your plant?



TO STOP SMASHING DIE STOPS, substitute a Vlier Spring Plunger for the usual square-head screw. The plunger actuates the automatic stop perfectly and, unlike the screw, never needs adjusting no matter how many times the die is resharpened. Available in four models: 50 sizes.



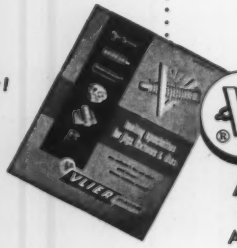
TO CUSHION SHOCK as the bed traverses, this surface grinder manufacturer uses two Vlier Spring Stops, reducing wear and tear on the machine. These clever, spring-loaded devices, ordinarily used on fixtures where the absence of side walls prevents the use of spring plungers, are now available in three standard sizes: 3 end pressures. Special sizes made to quantity orders.



TO LEVEL MACHINE TOOLS, electronic racks, benches, etc., use the *standard* Vlier leveling pad. The pad swivels to 7½° each side of the center line; adjusts automatically to uneven surfaces. Unique ball-joint design distributes weight over entire pad surface.

TO GET NEW IDEAS on how to save with Vlier Tooling Accessories, send for new 28-page booklet "Typical Applications of Vlier Tooling Accessories." It suggests dozens of ways to use these time-savers in both tooling and original equipment applications. Write for your copy today.

New catalog now ready! Send for your copy today.



Insist on Vlier Tooling Accessories... there's still no substitute for quality!

VLIER ENGINEERING CORPORATION

8900 Santa Monica Blvd., Los Angeles 46, California
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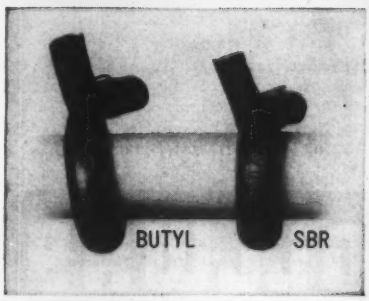

Butyl's high resistance to ozone is graphically demonstrated when compared with SBR or natural rubber

Enjay Butyl rubber has demonstrated for many years its outstanding ability to resist deterioration caused by sunlight and weathering. This inherent resistance of Butyl to ultra-violet light, ozone, oxidation, moisture and mildew, has made possible many new and colorful products. Butyl has also increased the life of other products such as weatherstrips, protective coating, garden hose, wading pools and many automotive parts.

Butyl *also* offers...outstanding resistance to chemicals, abrasion, tear and flexing . . . superior damping qualities . . . unmatched electrical properties and impermeability to gases and moisture.

For more information call or write the Enjay Company.

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ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N. Y.*

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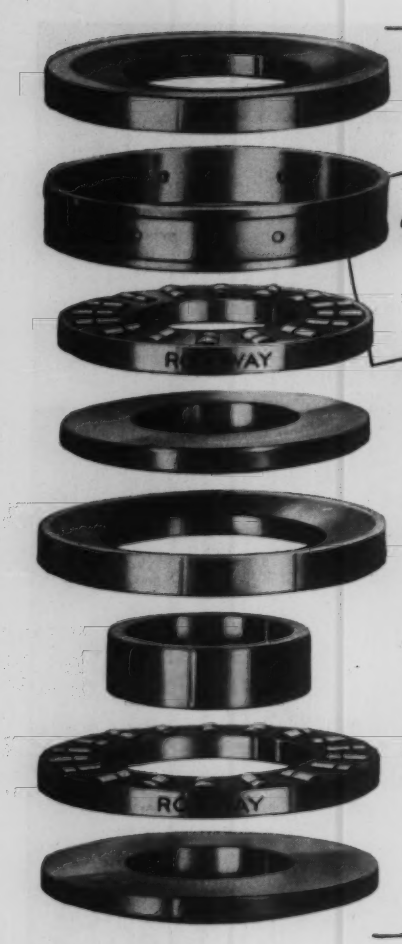

2 to 3 times Greater Thrust Capacity

8 to 12 times Longer Life Expectancy

New ROLLWAY TANDEM THRUST BEARING

Using axial space along the shaft, rather than enlarging the housing diameter, this new Rollway tandem thrust bearing distributes the load over two or three stages of roller components. Gives 2 to 3 times more thrust capacity than conventional thrust bearings. Life expectancy is 8 to 12 times longer depending upon the number of stages.

Each stage comprises a rotatable bearing plate . . . a bronze retainer with thru-hardened steel rollers . . . a compression sleeve . . . and a stationary bearing plate. The thrust load is applied to the first stage and is by-passed by each compression sleeve in turn to the remaining stage or stages.

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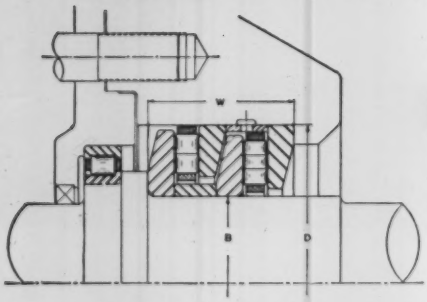
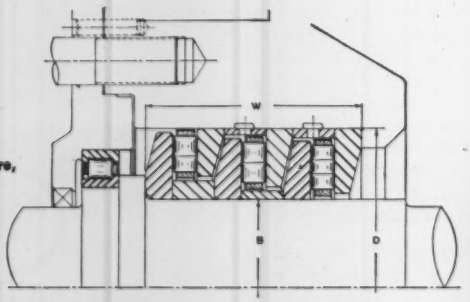


TWO STAGE TANDEM

22 sizes, up to 17" bore, 34" O.D., and 2,325,000 lb. capacity at 100 rpm



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Complete Specifications on Rollway Tandem Thrust Bearings, as well as other up-to-date information on bearing design is yours for the asking. See your Rollway engineer, or write: Rollway Bearing Company, Inc., Syracuse, N. Y.

Tandem Thrust Bearing manufactured by Rollway Bearing Company, Inc. under U.S. Patent Number 2,374,820.

ROLLWAY® BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Chicago • Toronto • Cleveland • Seattle • San Francisco • Boston • Detroit • Pittsburgh • Houston • Philadelphia • Los Angeles

Some Ideas

for your file of practical information on drafting and reproduction from

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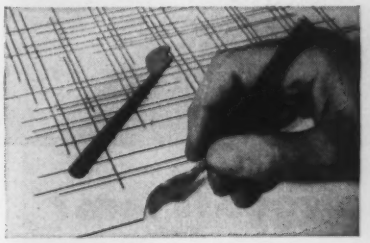

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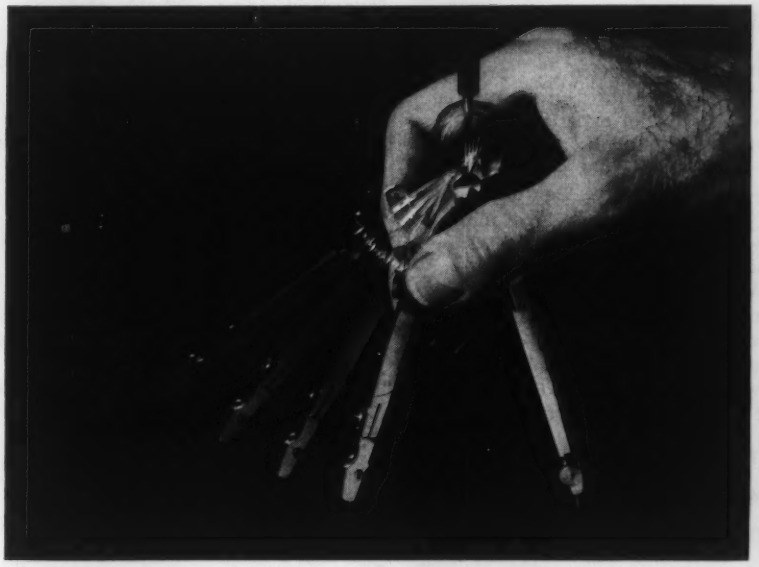

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Name & Title_____

Company & Address_____

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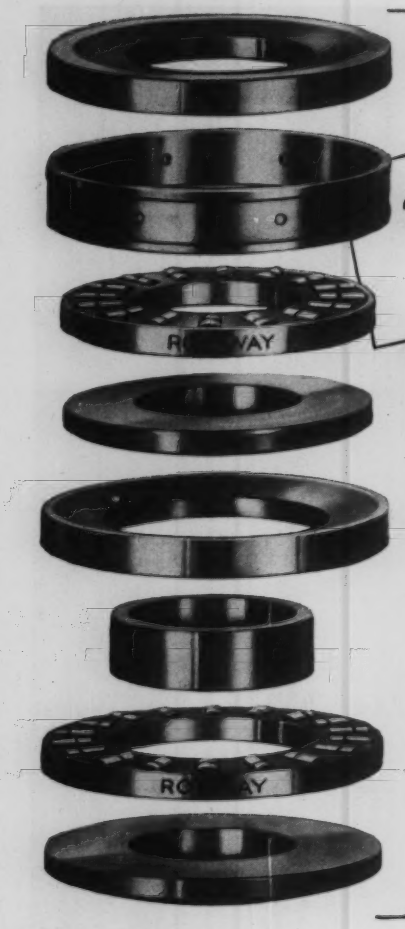

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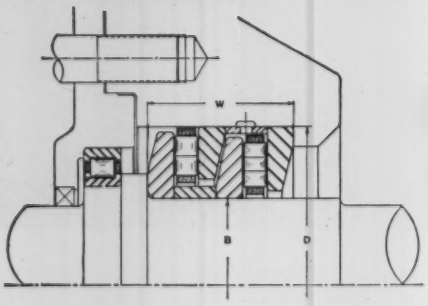

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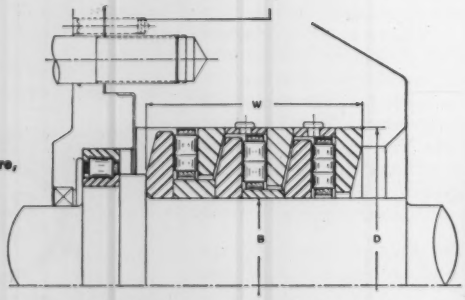

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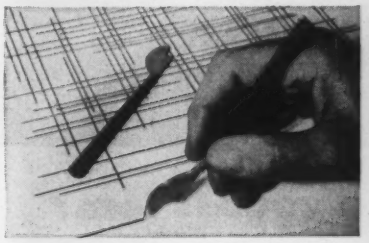

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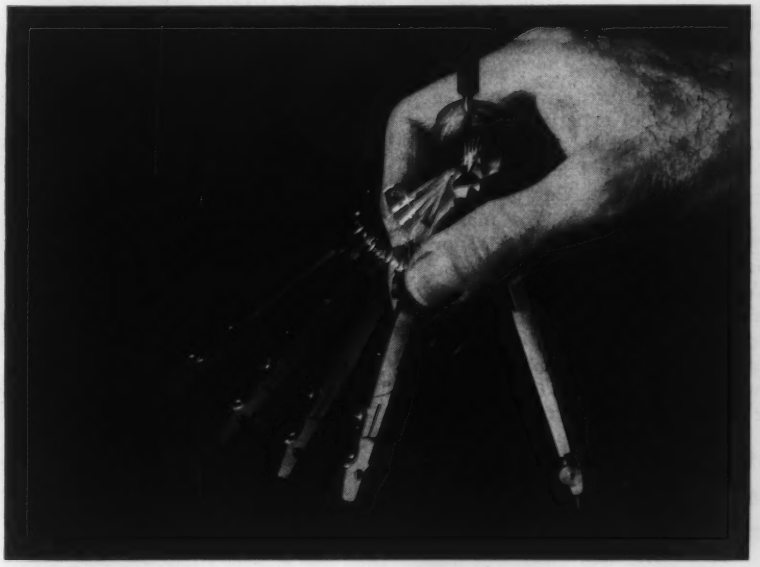

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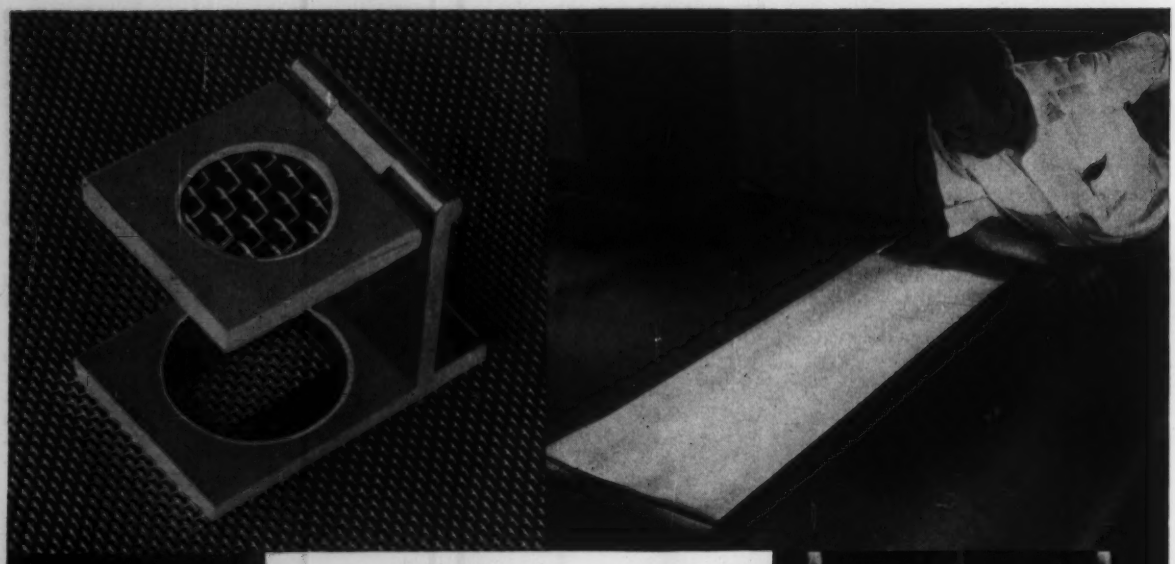

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CAMBRIDGE does . . .

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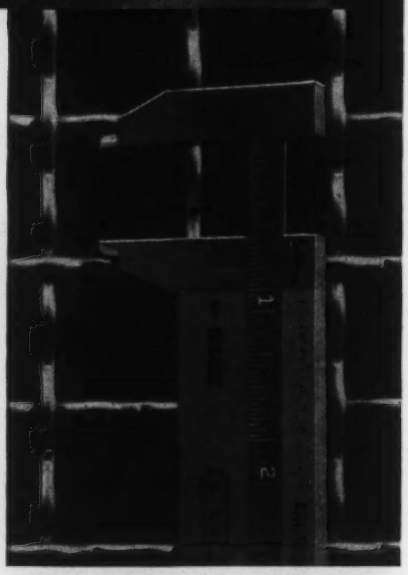
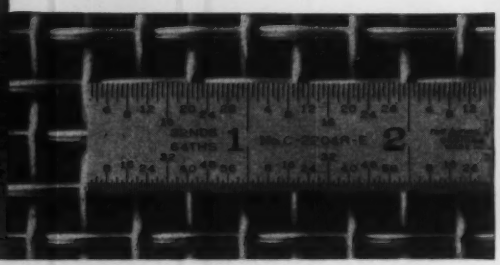




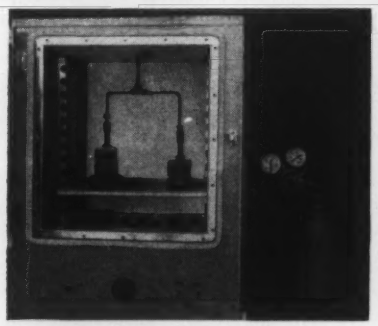
Technical data for gasket design and selection

Choosing a gasket for service under high heat, high loads

Combinations of elevated temperature and high flange loads—as found, for example, in compressor heads and automatic transmissions—often result in gasket extrusion and serious loss of bolt torque.

If internal pressures are also high, or contained fluids or gases may attack the gasket—as in refrigeration compressors—the service conditions become even more critical.

Accopac AN-890—a new beater-saturated asbestos gasket developed by Armstrong research—will seal under these rigorous conditions.



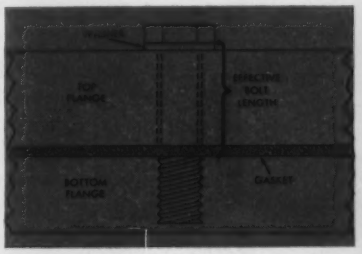
Laboratory test checks the combined effect of refrigerant gas and high temperature on Accopac AN-890. Flange at left contains refrigerant at 130 psi; flange at right contains no gas. After initial torquing at room temperature, flanges were heated to 300° F. and torque measured at 24-hour intervals for one week. Test showed no loss of torque on AN-890.

AN-890 is a blend of refined asbestos fibers and nitrile-type rubber that withstands temperatures up to 800° F. It will not crush or extrude under test loads of 100,000 psi at 300° F. And it has unusual torque retention and sealing properties in many applications where heat, high flange loads, and high internal pressures are encountered.

AN-890 is one of the line of Armstrong Accopac materials. It is available in rolls, sheets, ribbons, or die-cut parts. For more information, write for a copy of our folder IND-915.

How bolt length and initial torque loads affect torque retention on gasketed joints

To deal with problems of excessive torque loss in gasketed flanges—particularly those which operate at high temperatures—design engineers need to know (1) what the effect is of bolt length on maintaining torque; and (2) how the proportion of retained torque varies with the amount of initial torque.



Here, bolt length is defined as the distance from the underside of the bolt head to the face of the opposing flange—including compressed gasket thickness and any washer.

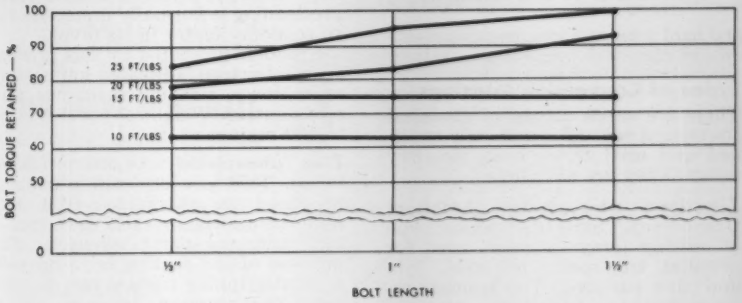
To get the answers to both questions simultaneously, Armstrong research engineers prepared separate steel flanges to accommodate three bolt lengths—½", 1", and 1½". (See diagram for definition of bolt length.) The flanges were gasketed with an Armstrong asbestos material—Accopac AN-890—in 1/32" gauge.

The bolts were torqued to specific loads at room temperature, and the flanges were placed in an oven at 300° F. After 18 hours, the torque was rechecked while the flanges were still hot. The results of this testing are shown on the chart below.

As this indicates, low initial torque loads lose proportionately more than higher loads. At 10 ft-lbs, for example, the average loss for all bolt sizes tested was 37%. At 25 ft-lbs, the average loss was about 8%.

The tests also show that longer bolts maintain torque better across the range of torque loads. The differences are, of course, more significant at the higher pressures. Although results in this direction were to be expected, the differences are surprisingly large.

If you have a specific problem related to torque retention on gasketed flanges . . . or any other question about the design, selection, or performance of gaskets . . . we will be glad to make suggestions to you. Send details to the address below.



Curves show % of initial bolt torque retained after 18 hours at 300° F. Initial torque is indicated at beginning of each curve. 5/16-24 NF hard steel bolts were used.

For your copy of our Gasket Design Manual, write to Armstrong Cork Co., Industrial Division, 7107 Dean St., Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

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(Advertisement)

AMCHEM Information Bulletin

A REVIEW OF PHOSPHATE COATINGS

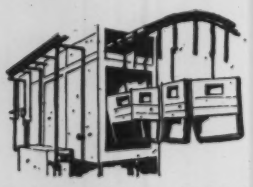
Specified for the Protection of Metal Surfaces

By HUGH GEHMAN, Assistant Manager, Product Development Dept., AMCHEM PRODUCTS, INC.

Phosphate coatings are protective inorganic finishes that actually change the chemical nature of metal surfaces. The metal reacts with the applied phosphate solution to form a nonmetallic, crystalline coating which serves to:

- Improve paint adhesion
- Provide protection against corrosion
- Increase lubricity of friction surfaces
- Facilitate mechanical deformation of metals
- Decorate—in many instances

Satisfactory protection of steel, zinc and aluminum surfaces against corrosion, paint peeling and blistering,



Typical automotive spray installation.

and hard wear requires precision methods of chemical conversion coating.

Types of Conversion Coatings

There are seven classes of chemical conversion coatings commonly specified and used throughout industry today. They are as follows:

Zinc-iron phosphate (Amchem Granodine). This is the heaviest type of coating (gray in color) used for prepaint treatments on steel, iron and zinc surfaces. The process requires five or six operations: cleaning; rinsing; rust removal, if necessary; coating; rinsing; and a second rinse. Coating weight ranges from 100 to 600 mg per sq. ft.

Medium or large volume production of automobile bodies, appliances, projectiles and cabinets can be handled effectively.

The coating solution improves paint adhesion by forming a crystalline deposit over the metal surface. This deposit is rough, as revealed microscopically, and so offers an ideal gripping surface for paint particles.

Manganese-iron phosphate (Amchem Thermoil-Granodine). This is a heavy black coating used on friction surfaces to prevent galling, scoring and seizing of parts. Typical metal parts treated are pistons, piston rings, gears, cylinder liners, camshafts, tappets and various small arms components.

Typical appliance treatment line.

Iron phosphate (Amchem Duridine). This is a comparatively new process that places a light coating on surfaces for improved paint adhesion. Since cleaning and coating occur in the same bath, it has only three to five stages.

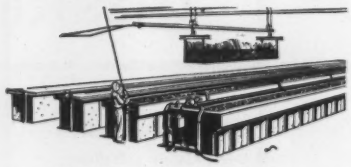
The iron phosphate treatment is a spray process suited for medium to large volume, large or small work. Precleaning is normally unnecessary, an economy factor in its favor.

Products protected by this process are steel or iron fabricated units, such as cabinets, washing machines and refrigerators. Weight of coating is 50 to 100 mg per sq. ft.

Zinc phosphate (Amchem Lithoform). This is a crystalline coating produced on galvanized iron and other zinc surfaces—also cadmium—for improving paint adhesion. The purpose of the coating is to provide a paint-gripping surface and to prevent the reaction between acidic components of the paint and the zinc metal, with the formation of soaps and loss of paint adhesion.

This coating is applied in weights of 75 to 500 mg per sq. ft. There are no limitations on volume or production or on size of products treated. Zinc phosphate coating is used on zinc alloy die castings, zinc or cadmium plated sheet or components, hot dip galvanized stock, and Galvanneal.

Amorphous phosphate (Amchem Alodine). This a protective coating for aluminum and aluminum alloys.

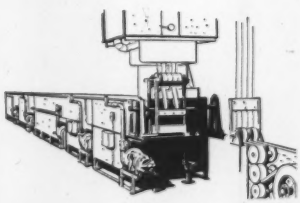


Typical aircraft dip installation.

It may be used in place of anodic deposition for improved paint adhesion and corrosion resistance.

This coating is practical for production in any volume. Coating weight is 100 to 600 mg per sq. ft. Products treated include aluminum awnings, doors and windows, aircraft and aircraft parts, missile parts, roofing and siding. Particularly good when aluminum is painted prior to forming.

Zinc-iron phosphate for oil absorption (Amchem Permadine). This is a relatively heavy coating adapted to the retention of rust-inhibiting drying or nondrying oils and waxes on ferrous metal surfaces. The coating is applied to a weight of 1000 to 4000 mg per sq. ft.



Typical continuous strip line installation.

The process is satisfactory for large or small work in any volume—nuts, bolts, hardware, guns, tools, etc.

Zinc-iron phosphate for metal forming (Amchem Granodraw). This is a specialized coating used in conjunction with a suitable lubricant to facilitate the cold mechanical deformation of steel. The coating acts as an anchor for the lubricant throughout drawing, extrusion, and cold forming operations.

It is a successful treatment for products such as blanks and shells for cold forming, heavy stampings, impact extruded shapes, drawn wire and tube.

For more complete information about any one or all of these chemical conversion coatings, contact an Amchem sales representative or write us at Ambler 18, Pa.

AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)

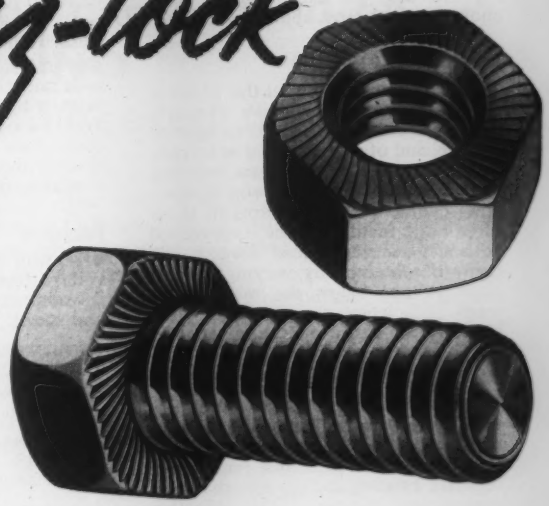
AMBLER 18, PA. • Detroit, Mich., St. Joseph, Mo., Niles, Calif., Windsor, Ont.

Amchem, Granodine, Thermoil-Granodine, Duridine, Lithoform, Alodine, Permadine and Granodraw are registered trademarks of Amchem Products, Inc.

Fascinating Fastener...

An exciting new and secret project dubbed "operation buzz nut" by plant and office employes is now revealed as a unique and fascinating idea in fasteners—MacLean-Fogg's new *Whiz-Lock*.

the MF *whiz-lock*



STARTLING RESULTS

Out of M-F research and development labs has come a lock nut that has amazed even those who first conceived it. A free-spinning surface-bearing lock and tension nut which surpassed expectations even in the earlier models.

The Whiz-Lock principle (an entirely new concept in fastening) has been a well-kept secret for over a year. Now patent applications are in—and this startling device is ready for designers, engineers and production men to uncover new properties and uses for this amazing fastener.

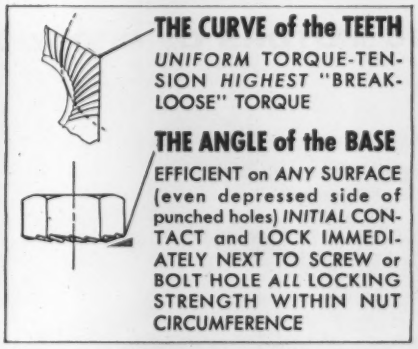
LOW COST, TOO

Whiz-Lock was released *only* when its *design* was capable of *precision* manufacture on *conventional* machinery. Thus *Whiz-Lock* is *NOT* a premium-priced nut!

Try this amazing Whiz-Lock test for yourself!

Apply a common nut with as much torque as you can. Torque to release it doesn't even reach application torque.

Now spin on a Whiz-Lock, tighten—and try to break it loose! (Caution: do not attempt on glass-top or light-weight desks.)

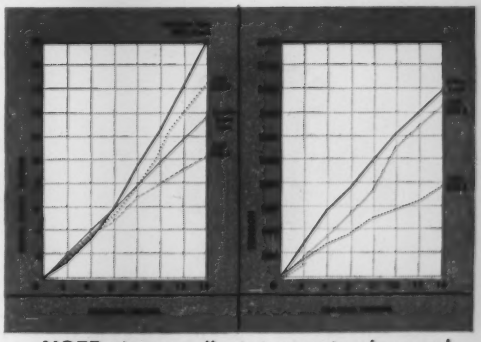

THE CURVE of the TEETH
UNIFORM TORQUE-TENSION HIGHEST "BREAK-LOOSE" TORQUE
THE ANGLE of the BASE
EFFICIENT on ANY SURFACE (even depressed side of punched holes) INITIAL CONTACT and LOCK IMMEDIATELY NEXT TO SCREW or BOLT HOLE ALL LOCKING STRENGTH WITHIN NUT CIRCUMFERENCE

The unequalled locking ability of the Whiz-Lock is only one of its many advantages to designers, engineers and production men.

• One piece • Free spinning • Very high tension • High strength—heat treated • High re-useability • Consistent—uniform torque tension • Highest release torque to application torque • Low cost

ON-and-OFF-TORQUE RATIO CHART

TORQUE-TENSION CHART



NOTE the excellent torque-tension and "apply and release" ratio of the M-F Whiz-Lock in *both* tests.

For oversize holes or wherever flange use is indicated, the same WHIZ-LOCK principle is available in flange nuts and screws.

SEND FOR BROCHURE...information on sizes and dimensions...M-F Whiz-Lock Nuts and Screws and M-F Flange Nuts and Screws

patents pending

MACLEAN-FOGG LOCK NUT COMPANY
5535 N. Wolcott Avenue • Chicago 40, Ill. • EDgewater 4-8420
IN CANADA: THE HOLDEN CO., LTD., MONTREAL

Circle 469 on Page 19

New line of precision sub-miniature DC motors with optional speed governors and gear trains

The new Cramer Type 810 sub-miniature DC motors have been perfected to meet the growing need for a unit combining very light weight with high efficiency and accurate speed control, in a standard ⅞" cylindrical frame. These motors are available with or without speed governors and gear trains, offering the user an exceptionally wide choice to meet most application needs.

Operation

Type 810 motors, without the addition of a speed governor, have a nearly linear relationship of speed to applied voltage, and of speed to load or torque. Precise control of armature winding permits an unlimited selection of operating characteristics in terms of these three basic factors. In the ungoverned versions, accurate speed control can easily be obtained by varying the applied voltage below the rated maximum. Efficiency remains high over virtually the entire operating range.

Speed Governors

These are of the internal, vibrating-reed type, regulating motor speed on the basis of average power supplied to the armature circuit, and require no separate brushes and no external arc-suppression network. The effective degree of speed regulation will depend on several factors in each instance. In general, however, under a combination of load and voltage variation the speed will not vary more than ±2% with a ±20% voltage change and a ±50% load change from nominal. The speed at which the unit regulates is set accurately at the factory, to meet the user's specified requirements.

Gear Trains

The addition of a gear train provides a wide range of output shaft speed reductions, with a corresponding increase of available output torque to a maximum continuous load of 50 ounce-inches. Seventy-three different gear ratios are available, from 48:1 to 13,000:1.

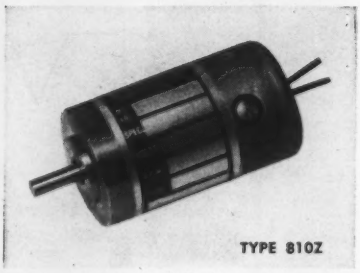
Features

OPERATING VOLTAGE—any specified DC voltage from 3 to 30 volts. Armature is wound for the specified voltage, load and speed.

OUTPUT SPEEDS — no-load speeds from 5,000 to 20,000 rpm, with different armature windings as required by the application.

SPEED REGULATION (governed) — ±2% for ±20% voltage change and ±50% load change from nominal.

ARMATURE — precision ground, Mylar insulated, lacquered and baked.



TYPE 810Z

COMMUTATOR — molded type, ground and polished.

BRUSHES — cartridge type for easy replacement, with springs soldered to brushes and holders to insure positive electrical connection.

MAGNET — Alnico VI, with machined pole pieces.

BEARINGS — precision ball bearings, life lubricated to meet the specific requirements of the application.

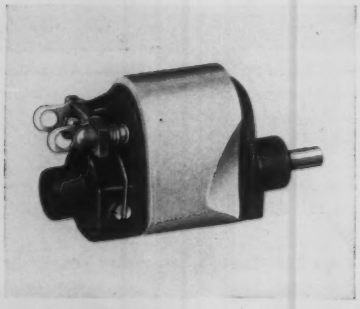
SHAFT — type 416 stainless steel.

GEAR TRAINS — precision-cut 120 pitch, integrally hobbed with pinions to minimize eccentricity.

HOUSINGS — anodized aluminum.

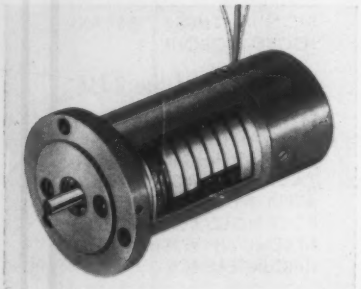
WEIGHTS — from 2.1 oz. to 4.7 oz., depending on choice of speed governor and gear trains.

THREE OTHER BASIC DC MOTORS OF BROAD USEFULNESS



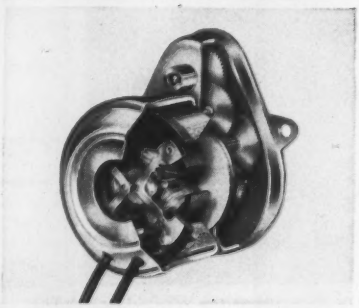
OPEN-FRAME MINIATURE **TYPE 820**

Type 820 resembles Type 810 (above) in its basic operating characteristics, and is even smaller in size and lighter in weight. Available only in standard form, without speed governor or gear train, it operates on any specified DC voltage from 3 to 30 volts. No-load output speeds range from 5,000 to 30,000 rpm, depending on armature winding. Special magnet design permits an extremely light weight of only 1.4 oz. DETAILS IN BULLETIN PB-820.



1 3/16" CYLINDRICAL **TYPE 830**

Type 830 is a slightly larger version of the basic ⅞" motor (Type 810), permitting larger load capacity at equivalent speeds, and is offered with or without speed governors. Armatures are wound for any specified voltage from 3 to 30 volts DC. No-load output speeds range from 5,000 to 20,000 rpm, depending on winding. Weights of ungoverned motor, approx. 8 oz.; governed, about 8.25 oz. Alternate mounting arrangements are available. DETAILS IN BULLETIN PB-830.



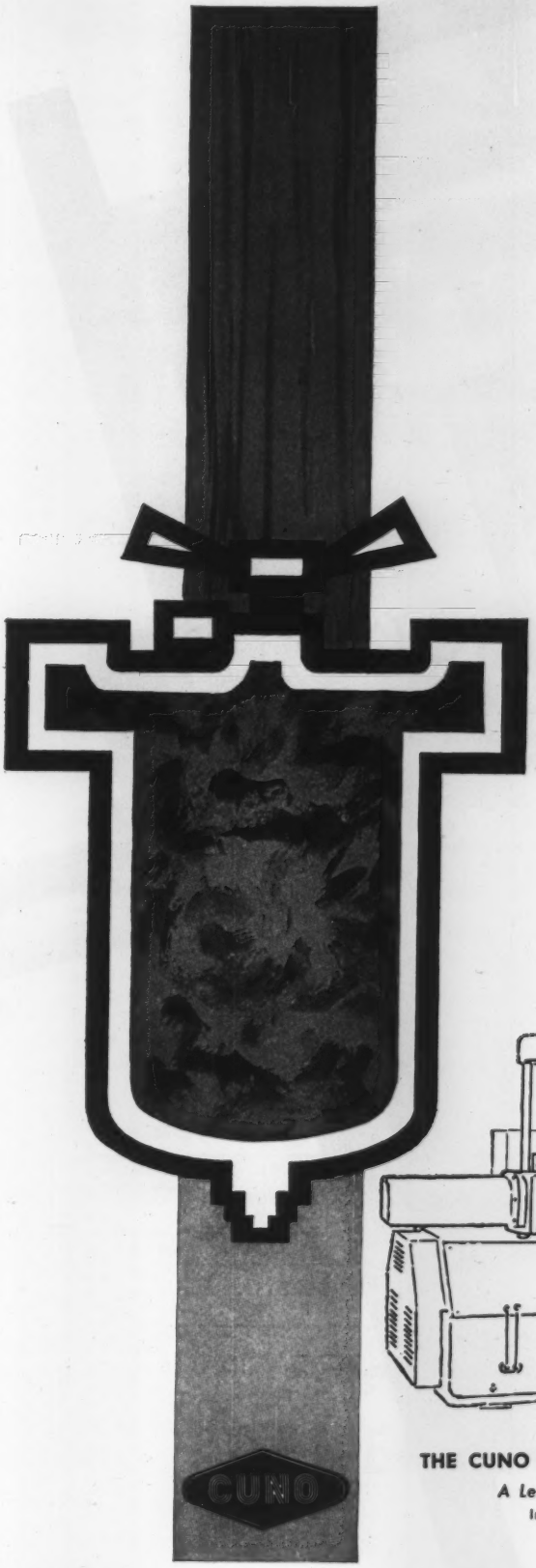
ELLIPTICAL GEAR TRAIN **TYPE 800**

Offering an unusually wide range of output speeds, with high torque, low current drain, and excellent speed characteristics. Output speeds from 2 rpd to 900 rpm, with torque as high as 30 oz-in. Operating voltage may be any specified value from 3 to 30v DC. Type 800 is also available without gear train, for output speeds from 960 to 3,000 rpm. Speed regulation is within ±10%, current drain as low as 30 ma. DETAILS IN BULLETIN PB-800.

CRAMER CONTROLS

CORPORATION

Box 6, Centerbrook, Connecticut

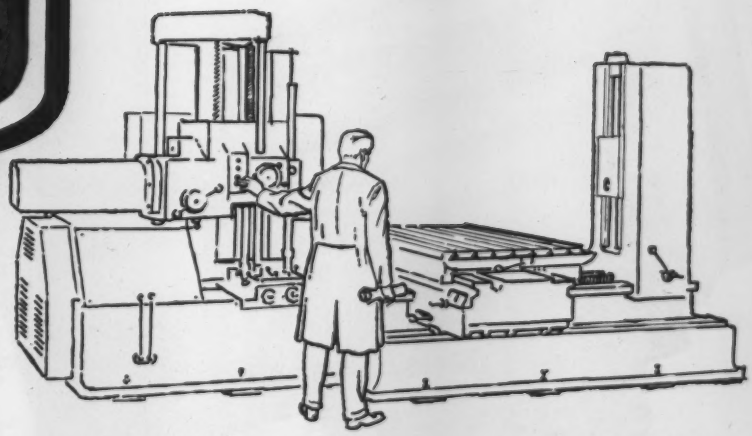


whatever the **machine tool application . . .** you can depend on **CUNO** engineered filtration

CUNO Filters are vital to the efficient operation of machine tool lubrication, hydraulic, and coolant systems. By removing damaging particles, they help reduce maintenance and replacement costs by protecting bearings, gears, valves, pumps, controls, etc. . . . help improve the quality of the product being manufactured.

Depending upon the specific application, CUNO offers you three basic filter types . . . CUNO Positive Self-Cleaning Edge-Type, CUNO Automatic Self-Cleaning Wire Wound Type, CUNO Disposable Depth Cartridge Filter . . . available in a variety of housings to meet *any* flow requirement.

Whenever *you* have a filtration problem—involving either a built-in application or a centralized system—write us. Our engineers will welcome the opportunity to demonstrate how you can *depend on* CUNO.



THE CUNO ENGINEERING CORP., Dept. 12, MERIDEN, CONN.

A Leader in Industrial Filtration for More Than 30 Years

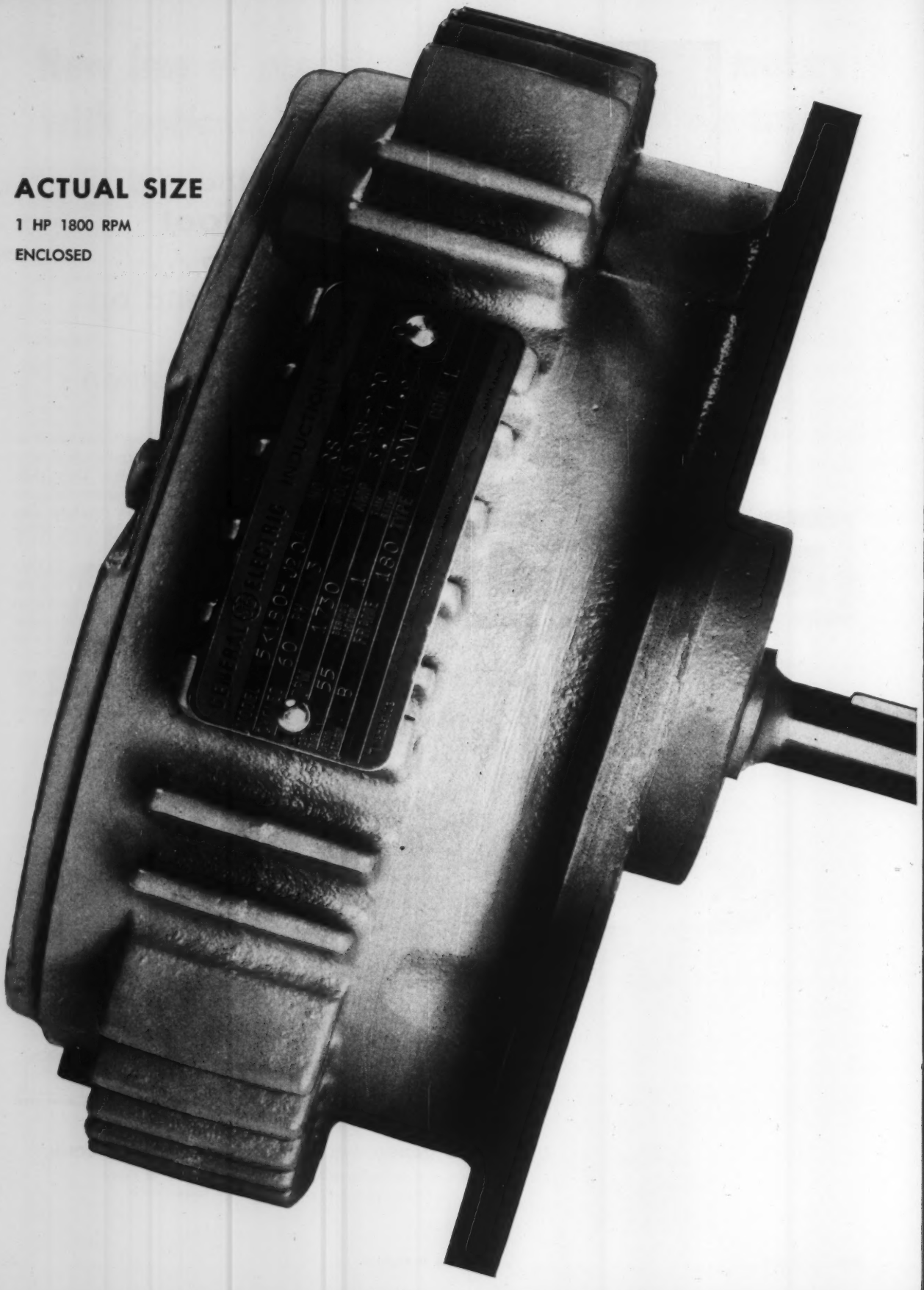
In Canada: Peacock Bros., Ltd., P. O. Box 1040, Montreal 3, P.Q.

Circle 471 on Page 19

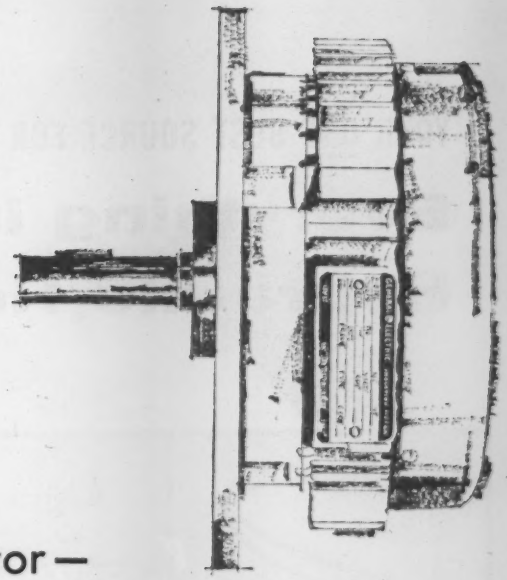
ACTUAL SIZE

1 HP 1800 RPM

ENCLOSED



NEW



General Electric Thinline Motor—

SHORT, LIGHT AND VERSATILE

You can easily eliminate one of your motor installation problems with General Electric's new polyphase motor for limited-space mounting.

Up to eight inches shorter and 26 pounds lighter than standard flange-mounted motors, General Electric's new Thinline motor will let you meet your horsepower requirements in considerably reduced installation space. By getting more horsepower in less space, you will be able to design more compact equipment in the future. On your present equipment, the Thinline motor's smaller overhang reduces required equipment space or gives operators more working area.

Easier to handle and position during installation, the Thinline motor minimizes mounting problems. Your assemblers will be able to work faster with less fatigue. And the 26-pound weight reduction lets you save substantially on shipping costs!

A wide choice of enclosures and mounting dimensions adds versatility to the Thinline motor's flange-type design. Thinline motors are available from 1 to 5 HP in both dripproof and totally-enclosed constructions.

Mounting versatility is provided by your choice of *three* mounting flanges for each Thinline motor rating. Any of the three available flanges (see the chart below) can be used for all-angle mounting—without adding to motor length.

You can get the answer to your Thinline motor application question simply by calling your nearby General Electric Apparatus Sales Office. If you have not received your copy of General Electric's Thinline motor publication, write to Section 840-28, General Electric Co., Schenectady, N. Y. Ask for Bulletin GEA-6927.

INTERCHANGEABLE FLANGE DIMENSIONS

Horsepower at 1800 rpm	Outside Diameter of Flange in Inches		
	Standard	Modified "D"	Alternate
1 hp	10.25	11	12
1½ and 2 hp	12	11	10.25
3 hp	13	11	14
5 hp	14	11	13

KNOWN APPLICATIONS

Fans and Blowers
Food Machinery
Textile Machinery
Floor Machinery
Paper Machinery
Pumps and Compressors
Machine Tools and Metalworking Machines

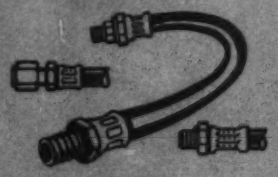
Progress Is Our Most Important Product

GENERAL ELECTRIC

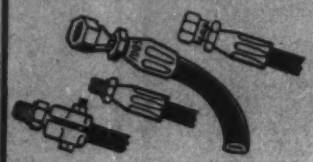
Circle 472 on Page 19

YOUR ONE BEST SOURCE FOR

Everything in Hydraulic Hose

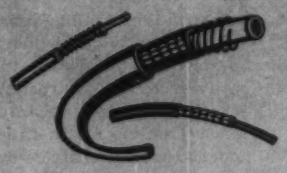


FACTORY PRESSED-ON ASSEMBLIES—Standard hose assemblies or to your specifications.

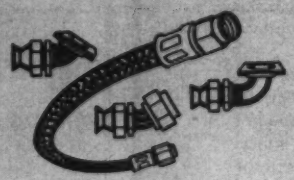


FIELD-ATTACHABLE FITTINGS—Popular for replacement . . . Easy-Grip hex requires no special tools.

BULK HOSE—Most complete range of types and sizes, for all industrial, automotive, and aircraft requirements.



LOW PRESSURE HOSE—Flexonics offers the most extensive line of low pressure hose available today.



TEFLON* HOSE—Flexonics offers a full range of stainless steel braided Teflon for steam and chemical applications.

* DU PONT TRADE MARK

EXPERT ENGINEERING—To assist in the selection and design of hose assemblies for your application.

For hose, hose assemblies, couplings and adapters in all sizes and designs . . . depend on Flexonics. Skilled Flexonics application engineers have more to work with . . . have unparalleled experience in supplying every segment of industry. For large or small requirements—standard or special—consult Flexonics.

WRITE TODAY FOR DESCRIPTIVE LITERATURE

IH-310

TOMORROW'S ENGINEERING TODAY

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INDUSTRIAL HOSE

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Divisions

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Flexonics Research Laboratories, Elgin, Illinois

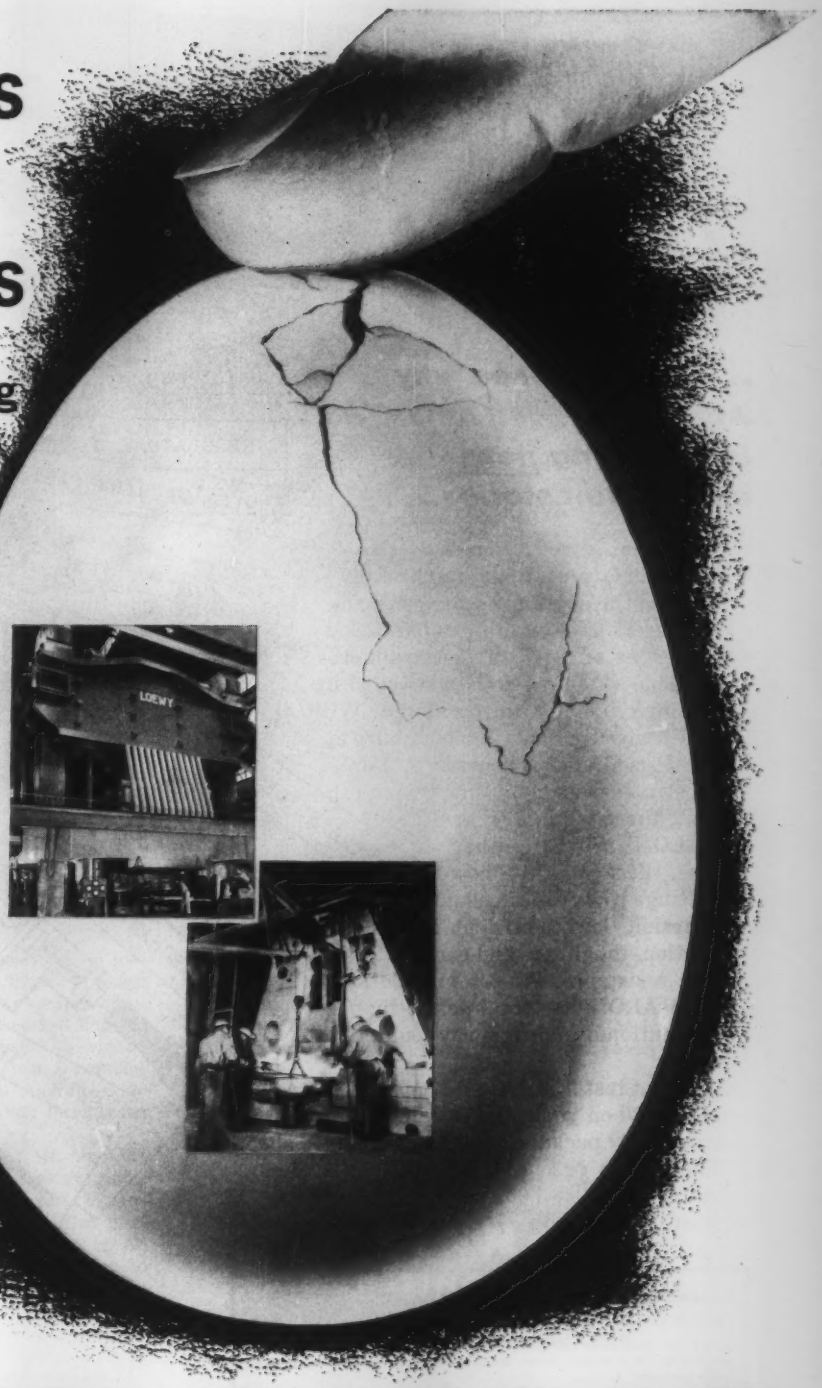
In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Circle 473 on Page 19

Hands of the Giants

crack an egg or shape a missile

100,000,000 lbs. of pressure—so delicately controlled that it can be made to crack the shell of an egg. Use the fabulous forces of present day forging skills to crack the barriers of space—weight, strength, high temperatures. Forge the future, today.



EST. 1883

WYMAN-GORDON

FORGING

ALUMINUM MAGNESIUM STEEL TITANIUM BERYLLIUM MOLYBDENUM COLUMBIUM
AND OTHER UNCOMMON MATERIALS

WORCESTER, MASSACHUSETTS

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DETROIT, MICHIGAN
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Circle 474 on Page 19

take a card ...ANY card!

...and you'll see why Acheson's EMRALON® is providing new application stories.

The recent introduction of 'EMRALON' surface coatings has literally "opened the door" for scores of manufacturers seeking the unparalleled properties of du Pont's tetrafluoroethylene (TFE) but handicapped by the high fusing temperature. With 'EMRALON' 310*, a one hour cure at 300°F. is all that is necessary. For substrates even more sensitive to heat, there is air drying 'EMRALON' 320†. In either case, these versatile new coatings provide excellent adhesion, low coefficient of friction, toughness and corrosion resistance. What's more, 'EMRALON' can be applied by conventional paint spray equipment.

Why not test 'EMRALON' 310 or 'EMRALON' 320 on your application. Send for an introductory package complete with data sheet. The cost is only $4.25 prepaid for enough material to coat 5,000 sq. in. of surface. ($4.50 west of the Rockies) Write today!

ACHESON COLLOIDS COMPANY
Dept. MD-79, Port Huron, Michigan

Gentlemen: Your new 'EMRALON' surface coatings suggest themselves as possibilities for a current design problem. Send an introductory package to me promptly.

☐ 'EMRALON' 310 (bake type) ☐ Check enclosed
☐ 'EMRALON' 320 (air-dry) ☐ Please have your service engineer call
☐ Bill me on Order No._____ ☐ Send descriptive literature

NAME: TITLE:
COMPANY:
ADDRESS:
CITY: STATE:
APPLICATION:

*'EMRALON' 310 is manufactured under exclusive license from E.I. du Pont de Nemours & Co. (Inc.) under U. S. Patent 2,825,706. Not licensed for use or for sale for use in providing electrical insulation.
†'EMRALON' 320 — Patent applied for

ACHESON *Colloids Company*
PORT HURON, MICHIGAN
A division of Acheson Industries, Inc.
Also Acheson Industries (Europe) Ltd. and affiliates, London, England

MT. VERNON DIE CASTINGS help STANLEY develop stronger, lighter, tougher heavy-duty builders' saws

CASE HISTORIES FROM MT. VERNON FILES

Stanley packs more power into its new line of low-cost, heavy-duty saws . . . and saves important weight doing it! They have been designed for greater utility, with such features as: Ball bearing guard — fingertip depth-or-bevel setting, uncluttered front — window brush-holder for simpler servicing, extra handling comfort, positive control, etc. Yet, with all these improvements, Stanley is still able to sell these better saws for less!

A big reason for this lower cost is Mt. Vernon's coordinated four-fold die casting service: designing, die-making, casting and machining. Mt. Vernon worked closely with Stanley* to create light, thin-walled aluminum castings with strength to spare. All parts are produced with excellent surface finish to facilitate barrel burnishing. Many fit together without machining thereby contributing to lower manufacturing and assembly costs.

Stanley is typical of the leading manufacturers in the power tool industry who know and rely on Mt. Vernon's experience and facilities for die cast zinc and aluminum parts. As the largest independent die casting company — with over 200,000 square feet under one roof — our services and equipment are ready to help solve your design and production problems. We'll be glad to discuss the advantages of die castings with you at any time. Just call your nearest Mt. Vernon sales representative.

*Stanley Electric Tools, New Britain, Conn.

MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

DIE CASTING RESEARCH FOUNDATION PARTICIPANT

SALES REPRESENTATIVES

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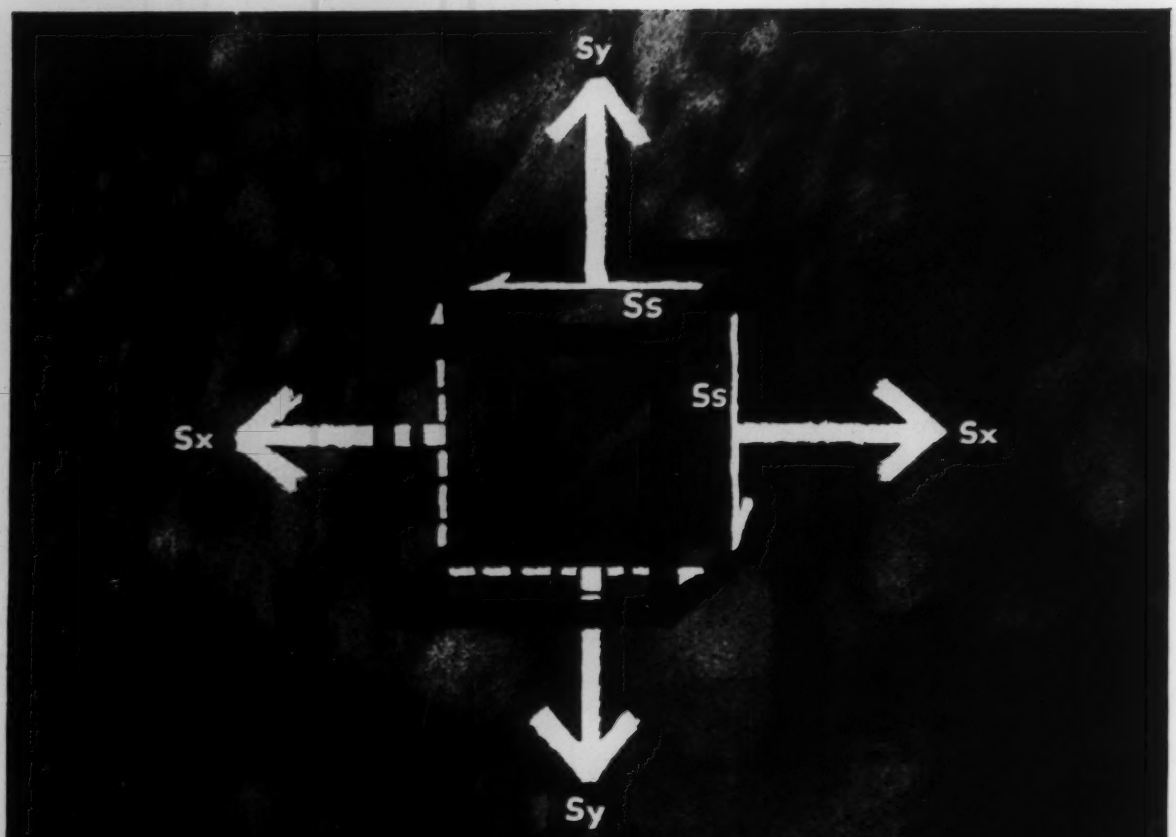


ASSIGNMENT:

ABRASIVE IMPACT

How Lukens *Application Research* helps you find the right steel plate for the job

If your assignment is designing equipment to withstand abrasive impact, our Application Engineering staff can serve you. Their specialty is helping you track down the precise steel plate for any job. They research a problem from the design stage right through to how the equipment has performed for years after its installation. This practical observation and experience—combined with metallurgical know-how—is yours for the asking. It's been saving our customers money for years.

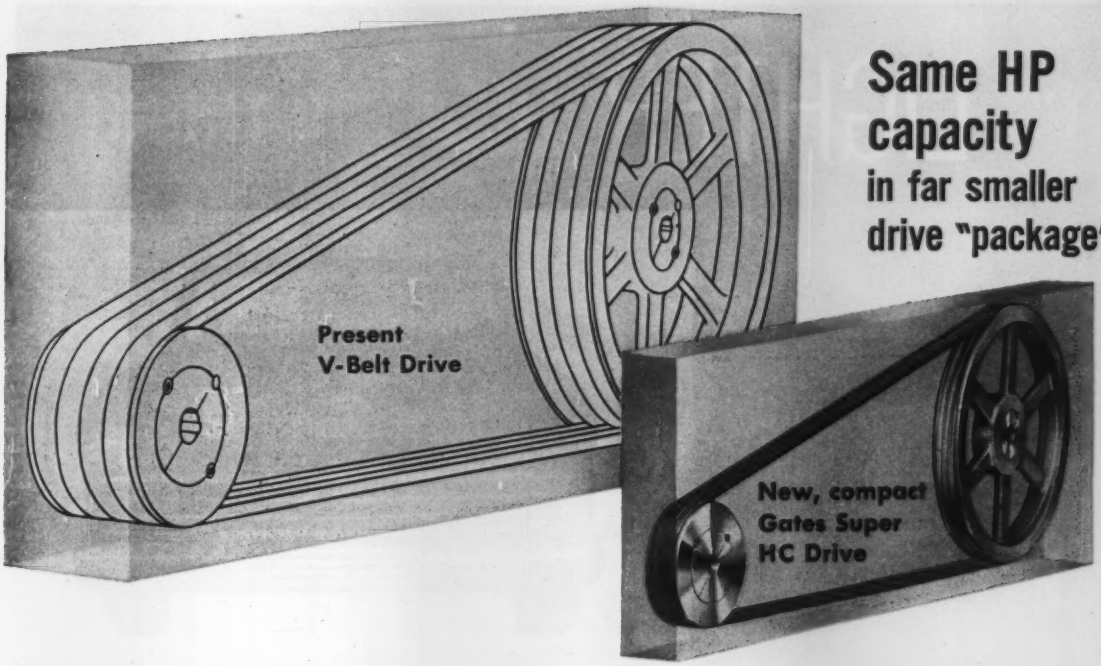
For example: working recently with a conveyor engineer, our people showed why 321 min. BHN quality Lukens "T-1" would perform equally as well as a previously used metal costing twice as much. On the other hand, the same group has suggested the regular quality of Lukens "T-1" for a uranium mine skip hoist, where a slightly softer steel will actually hold up longer. In still another conveyor application—in a coal preparation plant—our engineers demonstrated how stainless steel, Type 304, would produce long-term savings. The high initial cost of stainless was reduced by using it in Lukens clad plate form.

If your assignment is abrasive impact, why not let it be our assignment, too? Contact Manager, Application Engineering, E79 Services Building, Lukens Steel Company, Coatesville, Pa. Also ....

Helping Industry Choose Steels That Fit The Job

LUKENS

ASK FOR LUKENS "T-1" STEEL BULLETIN



Same HP capacity in far smaller drive "package"

New high capacity Gates V-Belt cuts drive space, weight and cost

Reduce size, cut costs! Gates new Super HC V-Belt puts power transmission in a smaller package—cuts costs all along the line!

Actually, this major advance in power transmission—a development of *specialized* research in the world's largest V-belt laboratories at Gates—makes possible the most compact, lightest-weight, lowest-cost multiple V-belt drive you can put on any machine. Sheave diameters can be reduced up to 50%, sheave widths 30% to 50%, center distances 20% and more.

Reduce drive cost as much as 20%

On new drives, the cost of a Gates Super HC V-Belt Drive is as much as 20% under the cost of present V-belt drives of the same hp capacity. Furthermore, smaller housings and bases—less materials, production time, shipping costs all reduce costs still further.

Learn more about the cost-saving Super HC Drive

"The Modern Way to Design Multiple V-Belt Drives" is an informative handbook on the Super HC Drive, available from your nearby Gates Distributor listed in the Yellow Pages under Belts or Belting.

The Super HC V-Belt

transmits same HP in much less space than belts now in use

Shown below are space savings of a typical installation:

	Drive R Sheave Diam.	Drive N Sheave Diam.	Center Distance	No. of Belts
Present Drive	7.4"	20.0"	42.9"	4
Super HC Drive	**5.3"**	**14.0"**	**30.0"**	**3**

TPA 423

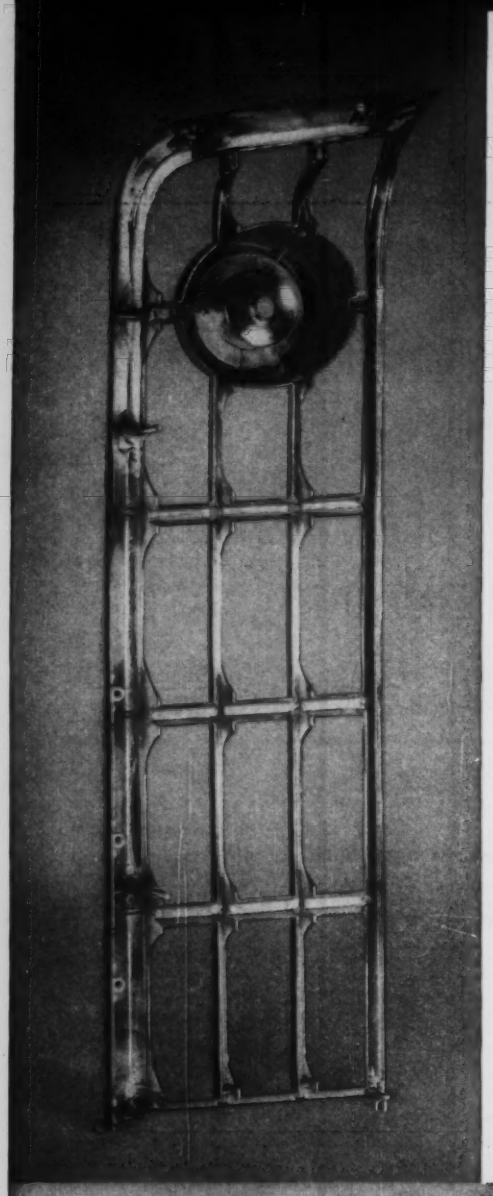
Gates

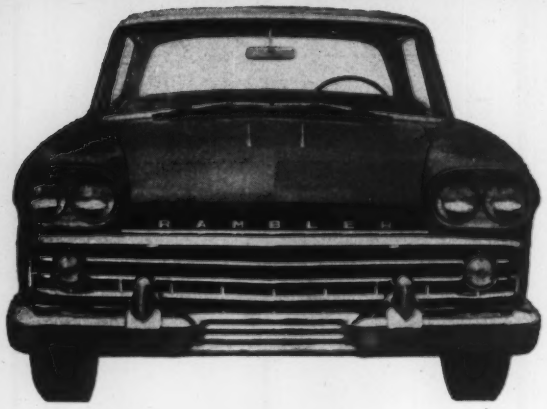
World's Largest Maker of V-Belts

The Gates Rubber Company • Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates Super HC V-Belt Drives

IT'S LIGHTER THAN YOU THINK!





...AND MAKES A STRONGER GRILLE WHEN DIE CAST with ZAMAK

Each half of this substantial 1959 RAMBLER grille is made of a single light-weight zinc die casting—for strength and rigidity—with long-lasting chromium plating.

Complete with integrally cast lamp housings and mounting studs for rapid assembly, the grille on this popular American Motors automobile is designed for appearance, durability and economy.

As in many other applications, rugged but extremely thin wall sections—possible only with ZINC die castings—minimize weight and are stronger **in proportion to thickness** than heavier sections.

Parts designed for ZAMAK alloy die casting will meet competition of either stampings or aluminum castings—and at lower cost.

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HORSE HEAD PRODUCTS ®

MACHINE DESIGN

July 9, 1959

The Delicate Balance

ENGINEERS and their employers—as well as engineering unions—have a vital interest in the current attitudes of engineers toward unions.

Today, in spite of union gains, engineers are mostly "agin." The inherent dislike which many engineers have for collective, leveling action is a powerful factor. Too, most employers seem to treat their engineers as professionals rather than as a labor commodity.

But the picture could change. A little carelessness on the part of management could tip the scale.

Two recent, independent surveys reveal remarkable agreement in their findings on attitudes, and on the factors that might lead to wider unionization of engineers.

One survey was conducted by MACHINE DESIGN and reported in the December 25, 1958, issue. The other was undertaken by the Bureau of Industrial Relations of the University of Michigan and reported in a recent book *Collective Bargaining as Viewed by Unorganized Engineers and Scientists*, by John W. Riegel.

In the University of Michigan study there were 264 respondents. Of these, 50 per cent were strongly antiunion (for engineers) and 23 per cent mildly so. Of the 11.5 per cent with mixed feelings, 6 per cent were slightly antiunion. Thus 73 to 79 per cent were against in more or less degree. Only 5 per cent were strongly in favor of unions for engineers.

Of the 313 nonunionized engineers among those responding to MACHINE DESIGN's survey, 58 per cent were strongly antiunion and 19 per cent were mildly so, for a total of 77 per cent against. Also, 5 per cent were strongly in favor.

Both surveys indicate that so long as engineers do not feel exploited or pushed around their natural attitudes will hold them back from union action. Many of Professor Riegel's respondents said, in effect, "I feel the company treats me right, so I'm not interested in collective bargaining. But if things were different, I might favor such action."

Management has the power to influence this attitude.

Colin Carmichael

EDITOR

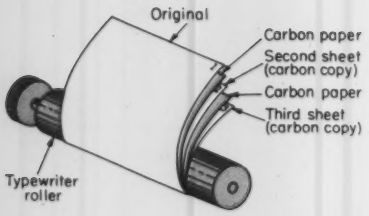
"Original"	
	If original exists as:
1	An opaque single sheet prepared on one or both sides with colored pencil, ball-point pen or typewriter.
2	An opaque single sheet printed on one or both sides, or carbon copy
3	Book or magazine page.
4	Translucent or transparent sheet prepared on one side only.
	If original is to be prepared as:
1	Typewritten work.
2	Line drawings and sketches.
	Copies required

ENGINEERING personnel, office managers, department heads, and office employees are constantly confronted with the problem of making copies of letters, drawings, articles, and similar printed or drawn material. It is often possible to obtain the most economical copy method by combining certain features of two processes or pieces of equipment. Selecting the right combination, however, depends on the type of "original" available or to be made for copying, the number of copies needed, amount of enlargement or reduction required, end use of the copies, and cost per copy. Often the cost becomes secondary when other factors are considered. Table 1 shows the least expensive method of copying specific originals for a required number of copies using the equipment described. Requirements for more than 5000 copies are generally handled by a commercial printer.

Basic guide to Copy

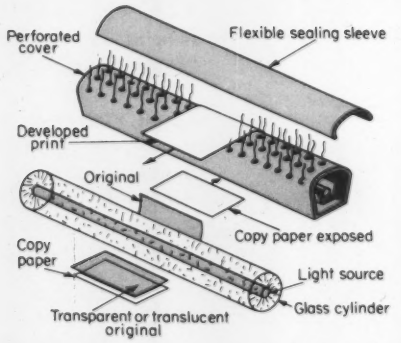
Reproduction Processes

Carbon Copies

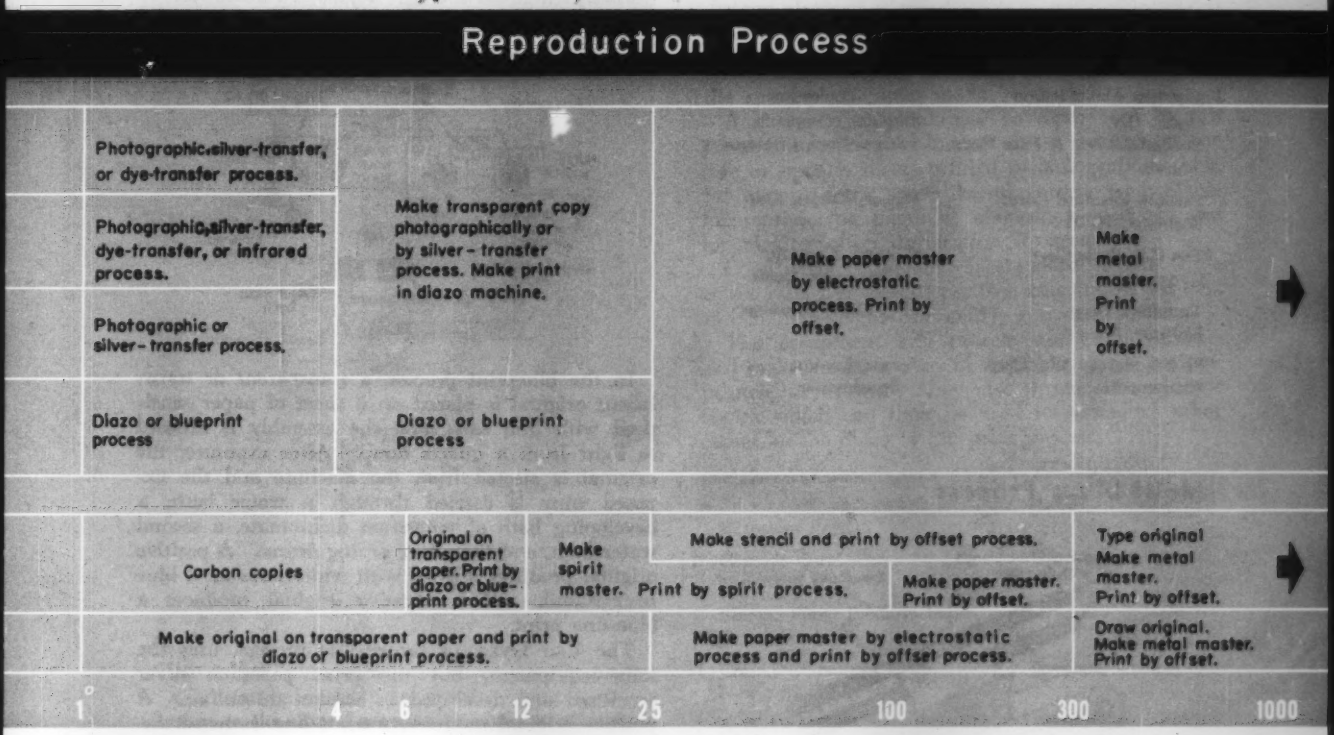


All office personnel are familiar with carbon copies. If a memo, letter, or drawing is originated in the office and approximately six copies are required, carbon copies are the cheapest method of reproduction. The approximate number of six depends on the kind of typewriter used, the carbon paper, the copy paper or second sheet, the typist's touch (on mechanical typewriters), and condition of the type face.

Dry-Diazo Process



The dry diazo process is also called the ammonia


Reproduction Process
Photographic, silver-transfer, or dye-transfer process.
Photographic, silver-transfer, dye-transfer, or infrared process.
Photographic or silver-transfer process.
Diazo or blueprint process
Make transparent copy photographically or by silver-transfer process. Make print in diazo machine.
Diazo or blueprint process
Make paper master by electrostatic process. Print by offset.
Make metal master. Print by offset.
Carbon copies
Original on transparent paper. Print by diazo or blue-print process.
Make spirit master.
Make stencil and print by offset process.
Print by spirit process.
Make paper master. Print by offset.
Type original Make metal master. Print by offset.
Make original on transparent paper and print by diazo or blueprint process.
Make paper master by electrostatic process and print by offset process.
Draw original. Make metal master. Print by offset.
1
4
6
12
25
100
300
1000

Processes and Equipment

For engineering departments and offices

process. It consists of placing a translucent original on top of an azo-dyed paper, exposing the matched pair to ultraviolet light with the light passing through the original, and then developng the paper by passing it through ammonia vapor. The resulting copy is a reproduction of the original, i.e., a positive from a positive or a negative from a negative, and is a dry print.

The image may be obtained in blue, black, or brown on various weights of paper (20-lb bond is standard), card stock, translucent paper, foil, photopaper, cloth, or plastic-coated paper. Equipment ranges in size from desk-top models to units which handle a 54-in. wide tracing. This process is extremely rapid and produces a copy in about 25 sec. An 8½ x 11-in. sheet of standard-weight azo-dyed paper costs approximately 0.6 cent.

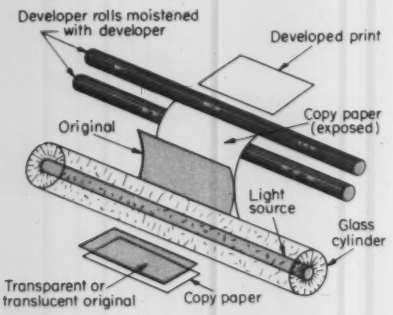
R. G. MURPHY
Manager of Engineering Services
Wallace & Tiernan Inc.
Belleville, N. J.

For all practical purposes, the dry diazo process is limited to the reproduction of translucent originals printed on only one side. Azo-dyed papers are not sensitive to daylight. Standard reproduction paper has fairly wide limits of exposure time in the machine, and excellent copies can be made for factory and office use. Prints are generally made on sheets cut to the same size as the original, but can also be run on rolls.

Most equipment presently manufactured will not leak ammonia when the exhaust is properly vented, and residual fumes in the prints are not objectionable. Machines do not require nightly cleaning.

Equipment Manufacturer	Tradename
Ozalid Div. General Aniline & Film Corp. Johnson City, N. Y.	Bambino, Ozomatic, Streamliner, Printmaster
Paragon-Revolute Corp. Rochester, N. Y.	Meteor, Comet, Star
The C.F. Pease Co. Chicago, Ill.	General, Century, Challenger, Scout
Technifax Corp. Holyoke, Mass.	HiQ Diazo Processer
Peck & Harvey Mfg. Corp. Chicago, Ill.	Arrow, Lancer, Speedmaster

Moist-Diazo Process



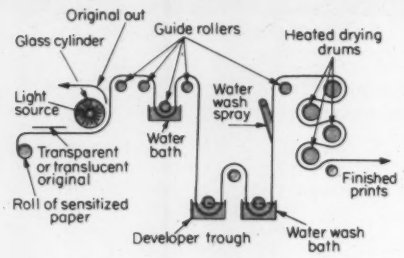
In this process, the sensitized paper is exposed in the same manner as in the dry diazo process. However, it is developed by passing the exposed print between two rollers moistened with developer. The print is discharged dry from the machine. Thus, a copy is produced in approximately 25 sec at a cost of 0.8 cent for paper in the 8½ x 11-in. size. For all practical purposes, original copy for this process is limited to translucent sheets printed on one side. Equipment for the moist diazo process ranges in size from desk-top models to units which handle 54-in. wide tracings.

Developer is prepared daily by mixing dry powder and water for storage in a reservoir. After each day's run, the reservoir, developing trough, and rollers must be flushed and rinsed with water.

Several types of paper are available for making prints. Standard reproduction papers are not sensitive to normal light, and may be stored in the open near the machine operator. As in the dry process, prints are generally made on sheets cut to the size of the original, but it is also possible to run roll stock in the equipment.

Equipment Manufacturer	Tradename
Charles Bruning Co. Inc. Mount Prospect, Ill.	Copyflex
Peck & Harvey Mfg. Corp. Chicago, Ill.	

Blueprint and Van Dyke Processes



In the blueprint process, a transparent or translucent original is placed on a sheet of paper sensitized with iron salts, and the assembly is exposed to light from a quartz lamp. After exposure, the original is ejected from the machine and the exposed copy is carried through a water bath, a developing bath of potassium dichromate, a second water bath, and then over drying drums. A positive original produces a print with white lines on a blue background, and a negative original produces a blue-line print.

The Van Dyke, or brown-line process, uses the same equipment, but the print paper is silver sensitized and developed in sodium thiosulfate. A positive original produces a white-line, brown-background print, and a negative original produces a brown-line print.

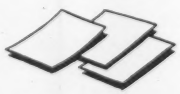
Blueprint of an 8½ x 11-in. original costs approximately ½ cent for paper, and the process is limited to making copies of transparent or translucent originals.

Because of the various washings and drying required, blueprints made in production machines are run only on roll stock threaded over rollers and through the baths. The length of paper threaded through the machine represents a delay in the production of a finished print. As the paper is discharged from the machine, the prints must be cut and trimmed. Total time for making a print is about 5 min.

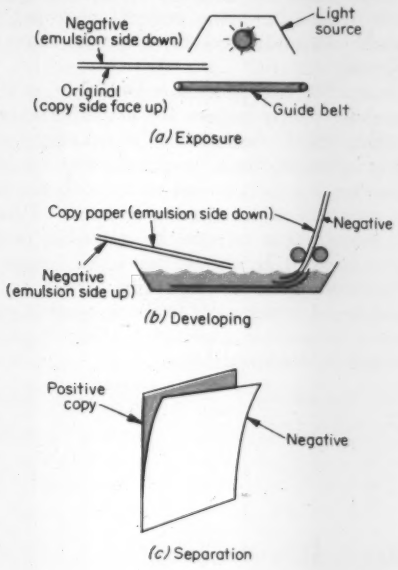
Installation of the equipment requires water and sewer lines and a power supply. At the end of each day the developing tank should be drained and flushed.

Blueprints are stable to light, and the process is very satisfactory for quantity production of large drawings.

Equipment Manufacturer	Tradename
Paragon-Revolute Corp. Rochester, N. Y.	
The C. F. Pease Co. Chicago, Ill.	Imperial



Silver-Transfer Process



Also called "photocopy," the silver-transfer process is a contact photographic process using a single solution to develop the copy. It consists of making a negative and, while the negative is still wet, making a positive copy from it. The original to be copied is placed face down on a piece of matrix or negative paper. The matrix is sensitive to strong light but can be handled briefly under ordinary office conditions. The assembly is then exposed to a strong light in the apparatus. After exposure, the negative paper is placed in contact, emulsion to emulsion, with a second sheet which is photographically sensitized.

The two sheets are then inserted into the developing unit. They advance through a developing solution between two rollers which remove the solution, press the sheets together, and discharge the assembly from the machine. After 10 sec, negative and copy are pulled apart. The matrix sheet is a reverse-reading negative generally discarded, and the positive is a copy of the original.

A single copy can be reproduced in 15 to 25 sec depending on equipment used. An 8½ x 11-in. copy on standard reproduction paper costs approximately 7½ cents for negative and positive papers. The normal procedure allows only one print to be made from each negative. However, a multicopy negative is available which will reproduce three or four copies before it must be discarded.

Equipment for this process is made by a number of manufacturers. Variations in the equipment are in the means of exposing, the amount of developer used, the means of filling the developer tank, the method of applying the developer to the negative, and the size sheet which can be reproduced. Equipment which will receive 19½-in. wide sheets is believed to be the largest available.

The same developer can be used for one to three weeks depending on the amount in the unit and the number of copies made.

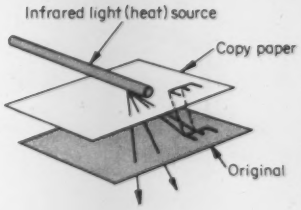
Any type of original may be reproduced by this process including transparent sheets printed on one side or opaque sheets printed on one or both sides. Equipment from some manufacturers is available for reproducing pages of magazines or books and for making offset duplication masters.

Copy paper is available in standard weight, white or color, as transparent positive, translucent positive, and in lightweight (air mail), and card stock.

The equipment and process are quite versatile and make an exact copy of anything typed, written, printed, or drawn. They also produce translucent copies which can then be used to reproduce other copies by the diazo or blueprint process.

Equipment Manufacturers	Tradename
American Photocopy Equipment Co. Evanston, Ill.	Apeco
Copease Corp. New York, N. Y.	Copease
Peerless Photo Products Inc. Shoreham, N. Y.	Dri-Stat
Cormac Photocopy Corp. New York, N. Y.	Corvette, Coronet
A. B. Dick Co. Chicago, Ill.	Photocopier
Peck & Harvey Mfg. Corp. Chicago, Ill.	

Infrared Process



In the infrared process, a sheet of paper sensitive to heat is placed on top of the original to be reproduced, and the assembly is fed into the apparatus. Under the infrared light in the machine, the carbon or metallic particles of the printing on the original are heated and transfer the heat to the sensitized paper to produce a copy in about 6 sec. An 8½ x 11-in. sheet of sensitized paper costs about 4½ cents.

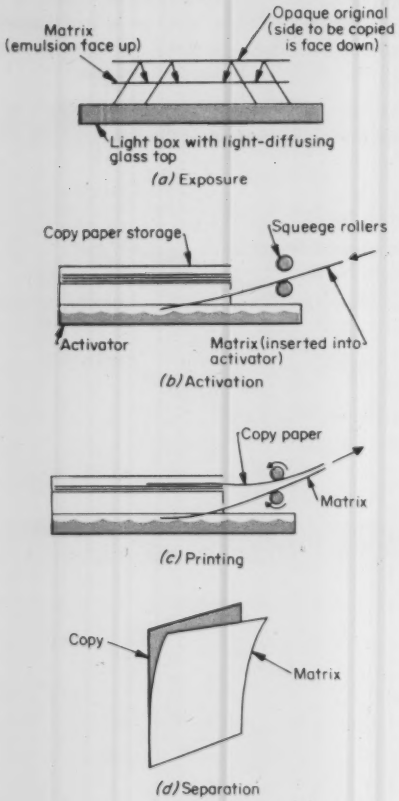
No chemicals or developers are required for this process which makes the apparatus more generally acceptable for office reproduction. Copies are produced dry and may be made from transparent sheets printed on one side or opaque sheets printed on one or both sides. The printed word or drawing must contain carbon or metallic particles which can be heated by the infrared light. In some

cases, letters, memos, or printed forms contain material which will not reproduce.

Equipment is available from only one manufacturer in several different models. Copy paper is available in several weights and colors, and is not sensitive to normal office lighting.

Equipment Manufacturer	Tradename
Minnesota Mining & Mfg. Co. St. Paul, Minn.	Thermofax

Dye-Transfer Process



In the dye-transfer process, the original document is laid face down on a sheet called a matrix. The assembly is placed in an exposing unit and exposed to light. The original may be a translucent sheet printed on one side or an opaque sheet printed on one or both sides. After exposure, the matrix is separated from the original and is inserted in an activator solution for 20 sec.

After activation, the matrix is withdrawn from the solution as two rollers force it into contact with a sheet of copy paper. Contact permits the dye in the matrix to transfer to the paper thus producing a copy of the original.

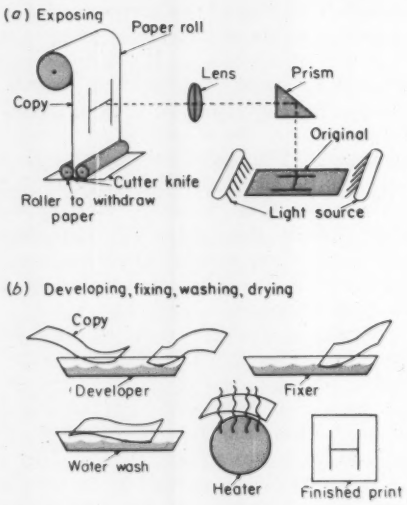
One advantage of this process is that up to five copies can be made in succession from one matrix by reactivating the matrix and repeating the developing operation. Copies produced are relatively dry. For a single 8½ x 11-in. copy, paper and matrix cost about 9 cents. If successive copies are made from the same matrix, cost per copy is reduced. Reproduction of a single copy takes about 60 sec.

Equipment for this process is available in several office models. Copy papers are available in standard weight, card stock, and translucent sheets. Activating solution, once prepared, can be left in the apparatus for periods up to a week depending on the number of matrices activated. Temperature of the solution affects the activating time of the matrix, and it is well to hold the temperature of the solution relatively constant.

An additional attachment to the apparatus permits preparation of master copies for offset duplicating work which is described later.

Equipment Manufacturer	Tradename
Eastman Kodak Co. Rochester, N. Y.	Verifax

Photographic Process



Photographic reproductions can be made by means of a camera and prism arrangement or by contact printing. With the camera or projection-type process, the original is placed on a table and illuminated. A prism arrangement above the table picks up the light beams reflecting the image of the original and bends them toward the lens of the camera. Suitable means are provided for rolling copy from the camera into a developer and then a fixative.

The copy is a direct-reading copy but is color reversed from the original. To obtain an exact duplicate of the original, a copy must be made of the first exposure which again reverses the color. Apparatus for this process is available from several manufacturers and can be purchased for hand or

automatic operation. A semiskilled operator is required.

Probably the major advantage of this equipment is its ability to enlarge or reduce the original copy. In one step, an original can be enlarged to double size or reduced to half size. Additional enlargement or reduction is possible by making subsequent copies.

Full processing from original to finished print requires about 45 min. An 8½ x 11-in. copy on standard type paper costs about 7½ cents for paper only. Any type of original material can be copied and reproduced on a variety of types of sensitized paper. This equipment is not considered general office equipment but should be part of an over-all reproduction department. In addition to capital investment, the process requires a print-washing area with water and sewer connections.

The contact photographic process is somewhat similar to the projection process. The type of copy produced and the chemical processing involved are the same for both. However, the exposure method is different. In the contact method, the process must be carried out in a darkroom. Sensitized paper is placed in contact with the original, and the assembly is exposed to light. After exposure, the print is developed, fixed, washed, and dried as in the projection process. This first copy is a reverse-reading and reverse-color negative and is generally not used as a print.

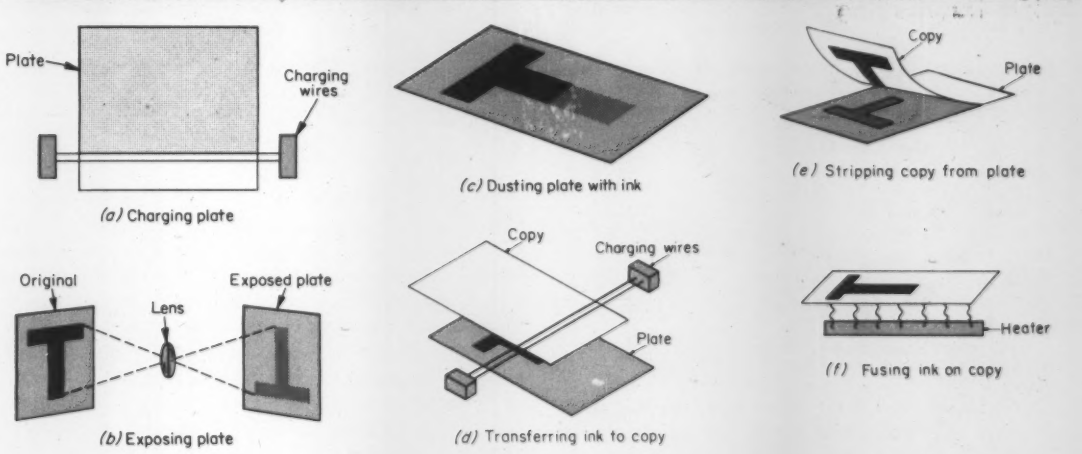
To obtain a usable print, a second copy must be made using the first as the original. In some cases, the first or negative copy is made on thin translucent paper. Even though this negative is a reverse of the original, it may be used to make prints in a diazo or blueprint machine. This is done by feeding the negative upside down into the apparatus and printing through the back of the copy.

Equipment for the contact process is not as versatile as the projection type but finds considerable use in engineering departments for cutting down drafting time. A negative is made, undesired portions are blocked out with india ink, and a positive copy is printed. The positive is then completed by filling in desired changes.

A copy by the contact process takes about 45 min. An 8½ x 11-in. copy costs about 7½ cents.

Equipment Manufacturer	Tradename
Photostat Corp. Rochester, N. Y.	Photostat
Haloid Xerox Inc. Rochester, N. Y.	Rectigraph

Electrostatic-Transfer Process



The electrostatic reproduction process is a dry copying process which uses an electrostatic force to deposit dry powder on a copy paper. A selenium-coated plate is given a positive electrical charge by passing it under a series of corona-discharge wires. The positive charge on the plate leaks off when the plate is exposed to light. The original to be reproduced is projected to the charged plate through a camera lens or by contact printing. Where light strikes the plate, the electrical charge is dissipated, but where the opaque material is on the original, the light is stopped and the positive electrical charge is retained on the plate.

After exposure, the plate is protected from light and inserted in a box frame where negatively charged particles of granular ink are allowed to flow over it. These particles are attracted to and held by the portion of the plate holding the positive charge of the original image. After the inking treatment, the plate is no longer light-sensitive and can be exposed without loss of image.

A sheet of paper is then placed over the image on the plate, and the assembly is again passed under the corona-discharge wires. This imparts a positive charge to the paper which attracts the negatively charged particles of ink from the plate

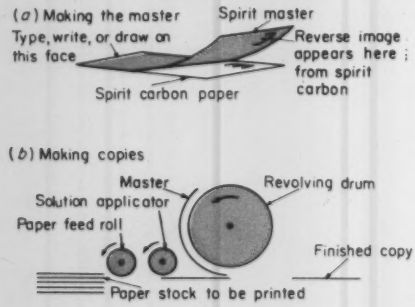
to the paper. The paper is peeled from the plate and exposed to heat for a few seconds which fuses the ink to form a permanent copy in the paper. The selenium-coated plate is cleaned by wiping with soft cotton and can then be reused.

The electrostatic-transfer process makes it possible to produce single copies on plain paper, offset paper masters, transparencies for offset metal plates and diazo machines, transparent overlays, and transparencies for visual aid projection slides. The equipment is made by one manufacturer. Originally, it was made for production of single copies, but a continuous production unit has recently been released. The equipment is not generally considered as office equipment, but in a reproduction department it represents an extremely versatile, time saving, and inexpensive way to make offset masters.

After initial purchase of the equipment, cost depends on the type of copy made and on the skill of the operator. A certain amount of skill is required, but the process has the advantage of not requiring solutions and always being ready for use. It is extremely versatile since it can copy anything and produces copy in about 3 min. Used in conjunction with a camera, this process can enlarge or reduce copy.

Equipment Manufacturer	Tradename
Haloid Xerox Inc. Rochester, N. Y.	Xerox

Spirit Duplicating



A spirit duplicator is an office machine that can produce up to 300 copies of typed, written, or drawn material. A special aniline-dye carbon paper is placed face up beneath a sheet of coated paper. As the message is typed or drawn on the front of the coated paper with a hard pencil, typewriter, or ball-point pen, a reversed copy is produced on the back of the coated sheet from the carbon paper. This coated sheet becomes a master copy and is placed on a drum in the duplicating machine.

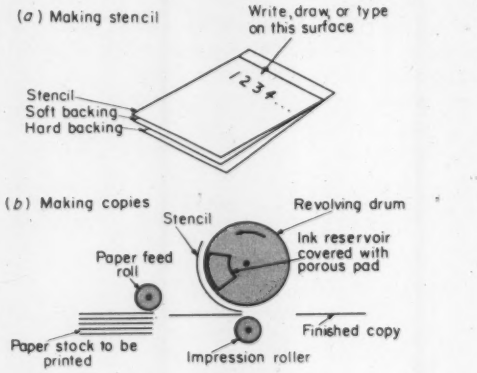
Paper to be printed is slightly moistened with a special solution on entering the machine. Contact with the master causes the solution to dissolve some of the aniline dye which is transferred to the paper, making a readable copy. Since a little dye is removed each time a copy is printed, the master has a limited life.

One general objection to this process is the staining of personnel with the aniline dye when masters are carelessly handled. This is being overcome by several manufacturers who are treating the masters with a wax which can be dissolved only by a modified solution.

Clarity of the copies decreases as the master becomes exhausted. However, for a short run of order forms, for example, or a longer run of material such as bulletin-board memos, this process is quick and inexpensive.

Equipment Manufacturer	Tradename
Ditto Inc. Chicago, Ill.	Ditto
A. B. Dick Co. Chicago, Ill.	Azograph

Stencil Duplicating



Stencil duplicating is also called mimeograph. "Mimeograph" was originally a trademark of the first manufacturer, but has become accepted as part of the language. The term is used freely to describe the process even though the equipment is made by a number of manufacturers.

Stencil sheets are made of porous tissue covered with a coating that is impervious to ink. Typing or drawing on these sheets with a sharp instrument pushes the coating aside and exposes the porous tissue. The stencil is wrapped around an inky cylinder, and the cylinder is rolled across a piece of paper. Ink is forced through the porous parts of the stencil onto the paper, thus duplicating the message originally typed or drawn.

Stencils may also be prepared mechanically by an electronic scanning device. The original copy is mounted on one drum of the machine and a stencil on a second drum. When the machine is started, a device scans the original, picks up the location of the image, and reproduces it in small dots on the stencil. The process takes about 6 min.

Mimeograph is an inexpensive means of duplicating and is generally used for bulletins, forms, memos, and letters. Operation of the equipment

is simple, and it is possible to train personnel quickly. The versatility of the process depends on the care and ingenuity in preparing the stencil. A stencil costs approximately 15 cents and paper for a copy about 0.2 cent. The machines produce about 150 copies per minute, and several thousand copies can be run from one stencil.

The stencil, once prepared, is somewhat delicate, and must be handled with care. Copies are usually made on paper with a soft surface which will readily absorb the ink and dry quickly. Because of the soft surface, there is a slight tendency for the letters to bleed into the paper. This leaves a fuzzier letter than is obtained in the offset process.

Mimeograph machines are available from several manufacturers in sizes from desk-top to floor-mounted models.

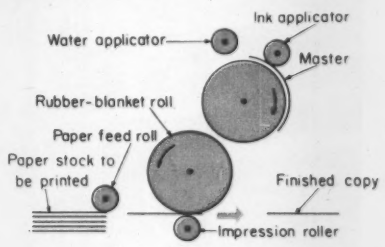
Equipment Manufacturer

Ditto Inc.
Chicago, Ill.

A. B. Dick Co.
Chicago, Ill.

Gestetner Duplicator Corp.
Yonkers, N. Y.

Offset Duplicating



An offset duplicator will do anything a mimeograph machine will do, and more. However, it involves a larger capital expense, is more demanding on the operator, and is at its best when used continuously rather than intermittently.

For the offset process, a master copy on paper or metal must be prepared. Choice of a paper or metal master generally depends on the number of copies required. Paper is used for approximately 400 copies or less and metal for more than 400 copies. However, photographic-film negatives can be used to make metal plates or photo-sensitive plastic-coated paper plates and, here, the number of copies required is not the determining factor.

Paper masters can be typed or drawn or may be prepared by the electrostatic-transfer process. Typing a paper master requires a special greasy-ink ribbon to properly duplicate in the offset press. A paper master costs about 6 cents and a metal master about 50 cents.

The offset process is based on the principle that oil and water do not mix. The image placed on the master is receptive to the greasy ink used in the press. The master is mounted on a circular drum and clamped in place. When the machine is started, the drum revolves, and a smaller roller moistened with water is brought into contact with the master to wet the surface. The water, however, will not cover the greasy ink image.

After the master is moistened, an inked roll is brought into contact with the revolving drum. Ink is deposited in a film on the image but is repelled by the water-covered surface. Ink from the image is then transferred to a rubber blanket which contacts the copy paper and makes the print. The image is direct-reading and positive on the master, reverse-reading on the rubber blanket, and direct-reading on the copy paper.

Offset copies may be made on a variety of types of paper, from 13-lb bond to card-weight stock. A single copy on 20-lb bond costs about 0.2 cent for the paper. Equipment for this process is made by several manufacturers. Presses are available for reproduction of 8½ x 11-in. copies up to 36 x 48 in. Larger presses are used by commercial printers. An offset press requires a skilled operator or a person who has been carefully trained.

Equipment Manufacturer

Addressograph-Multigraph Corp.
Cleveland, Ohio

A. B. Dick Co.
Chicago, Ill.

Davidson Corp.
Brooklyn, N. Y.

Planetary Gearing

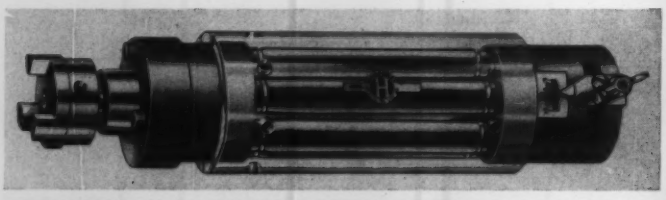
In "Planetary Gear Drives" June 11 issue, the sentence following Equation 16 on Page 147 should be: In this equation, ω_A will have a negative value when ω_H is positive.

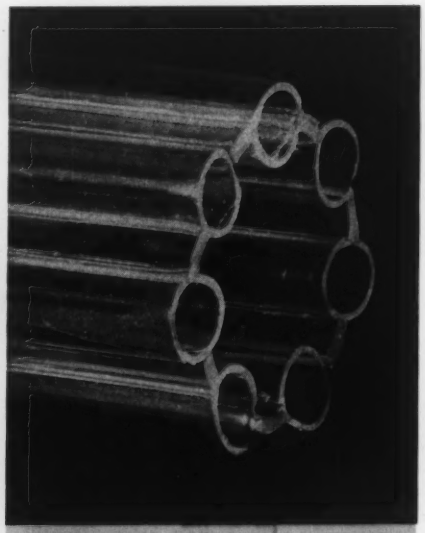
They Say . . .

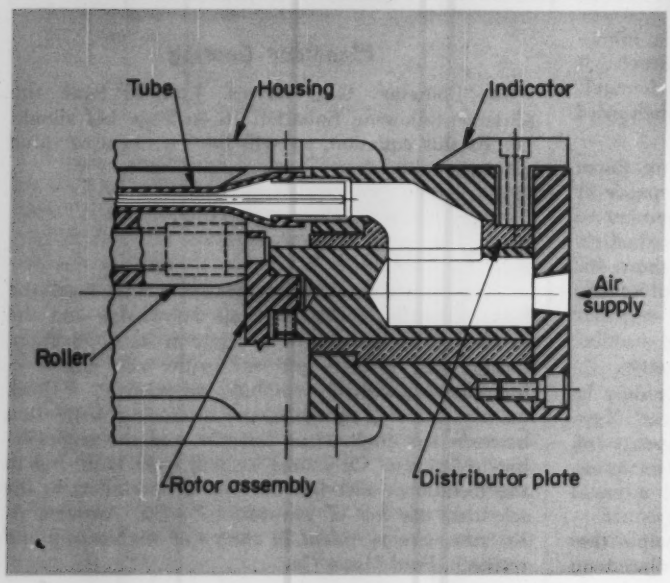
"The future engineering graduate will need the basic scientific ability to create knowledge and the basic engineering ability to envision its application. I think we'll have to get used to the term engineering scientist, with the emphasis on scientist. I think we also have to recognize the increasing distinction between the engineering scientist and the engineering technician. Of course we will need both, but to the technician will fall the job of operation; to the scientist, the job of innovation."—Dr. Andrew A. Kucher, *vice president in charge of engineering and research, Ford Motor Co.*

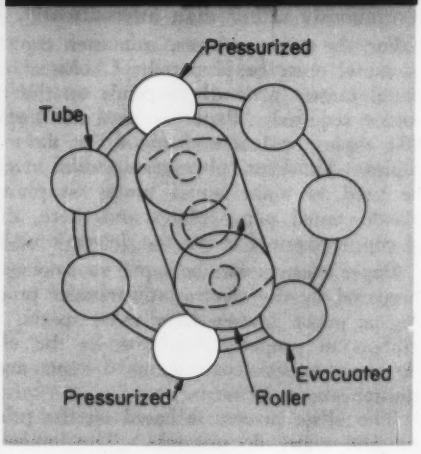
scanning the field for *ideas*

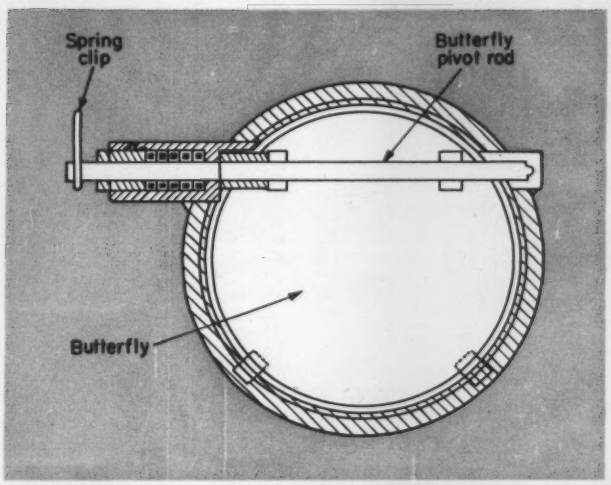
Pulsating power tubes drive motor rotor at infinitely variable speeds. Air, or any other fluid, is introduced under pressure into a distributor valve which rotates at same speed as output shaft. Two diametrically opposed ports in the distributor admit the pressurized fluid into a series of flexible polyvinal tubes which surround the rotor. As the tubes are inflated, a turning moment is applied to the rotor. Since two tubes are always energized, the motor starts instantly with a high initial torque. A rotating valve exhausts the fluid from the tubes in the proper sequence. An adjustable sleeve between the distributor and the inlet times the unit for maximum efficiency. Speed control is obtained by adjusting the air supply pressure and the distributor-valve plate position. Design developed by Humphrey Products Div., General Gas Light Co., Kalamazoo, Mich.



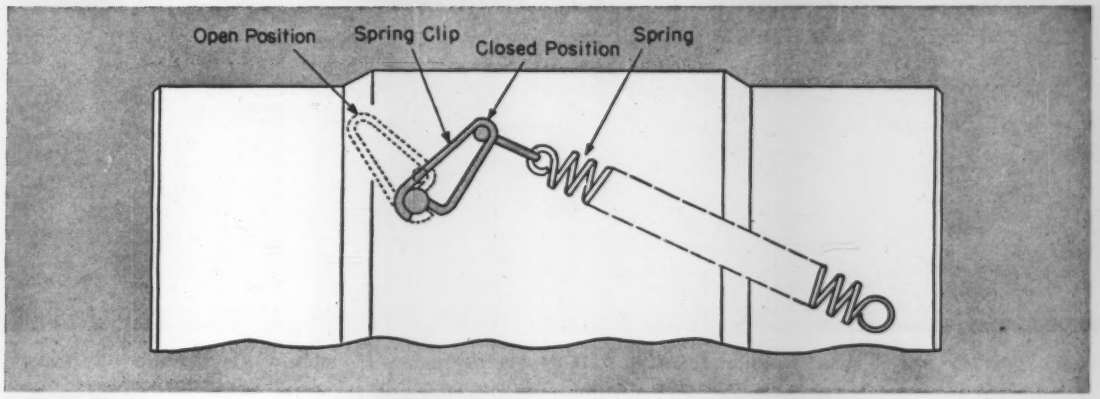


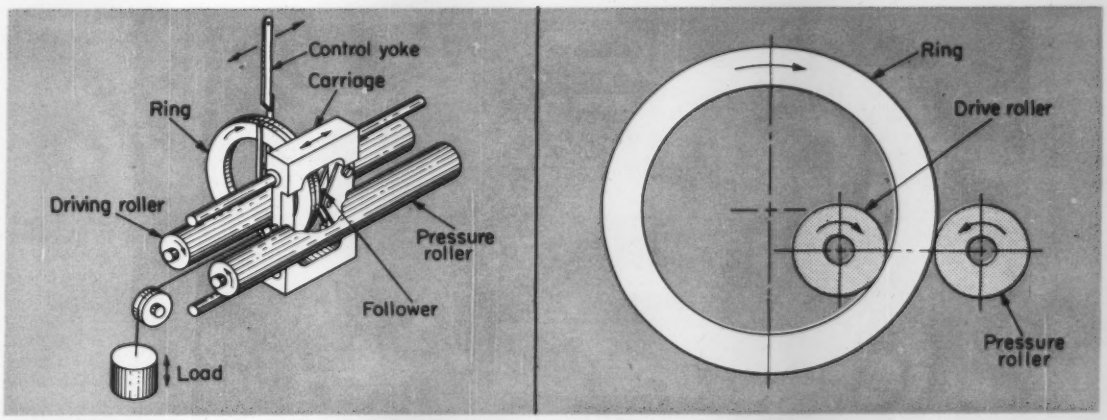




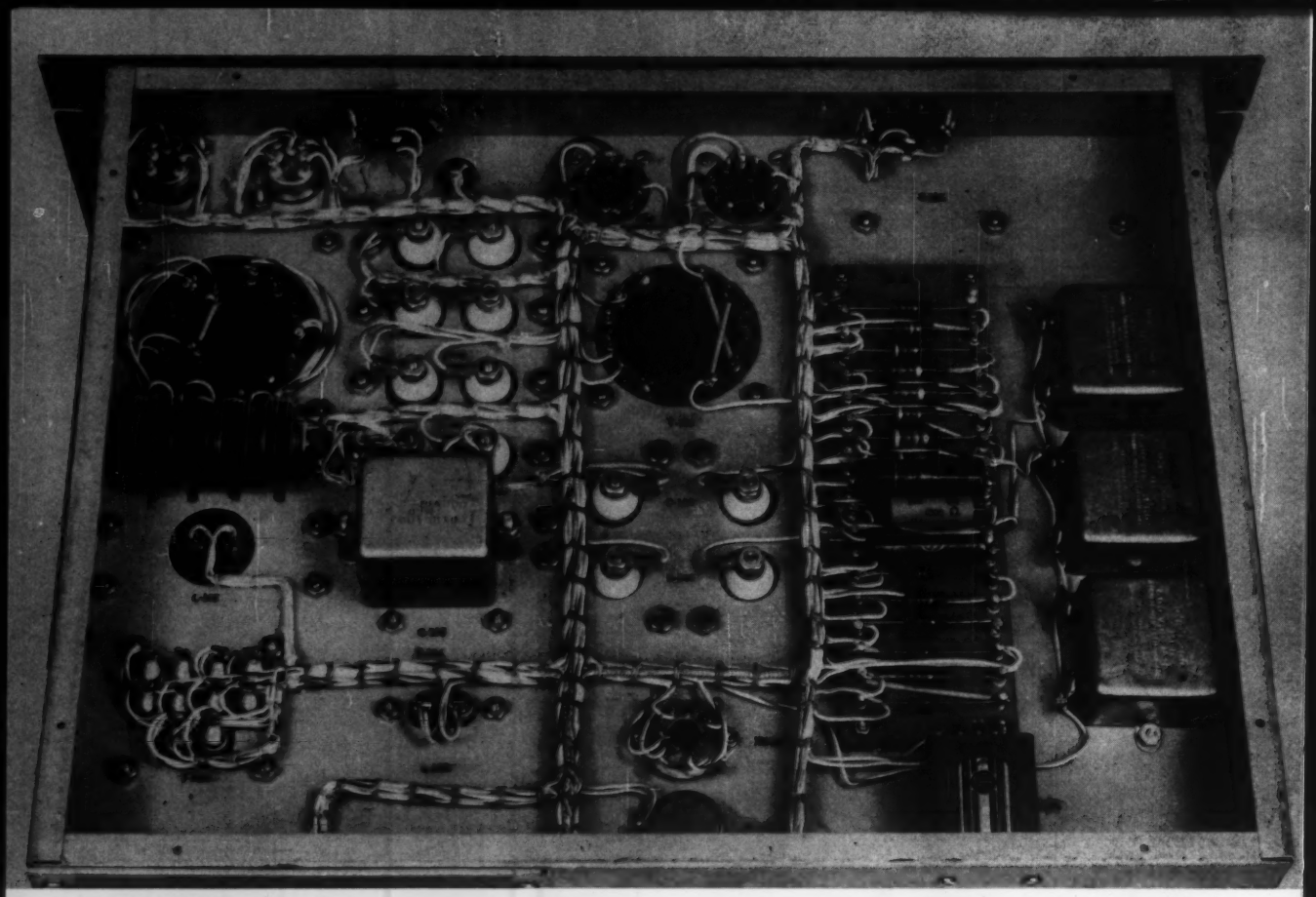


Toggle-linkage control of spring-loaded butterfly valve reduces torque required to keep valve open but provides snap-action closure. In a valve developed by Dorsey Drip Regulator Corp., a triangular clip controls the spring action. As flow through the valve increases, the butterfly opens against the spring initially. When the butterfly passes the half-open position, the spring end slides down the clip to the axis of butterfly rotation, reducing the spring force and, hence, the torque required to fully open the valve. When the butterfly passes through the half-open position during closure, spring action snaps the valve back to the normally closed position.





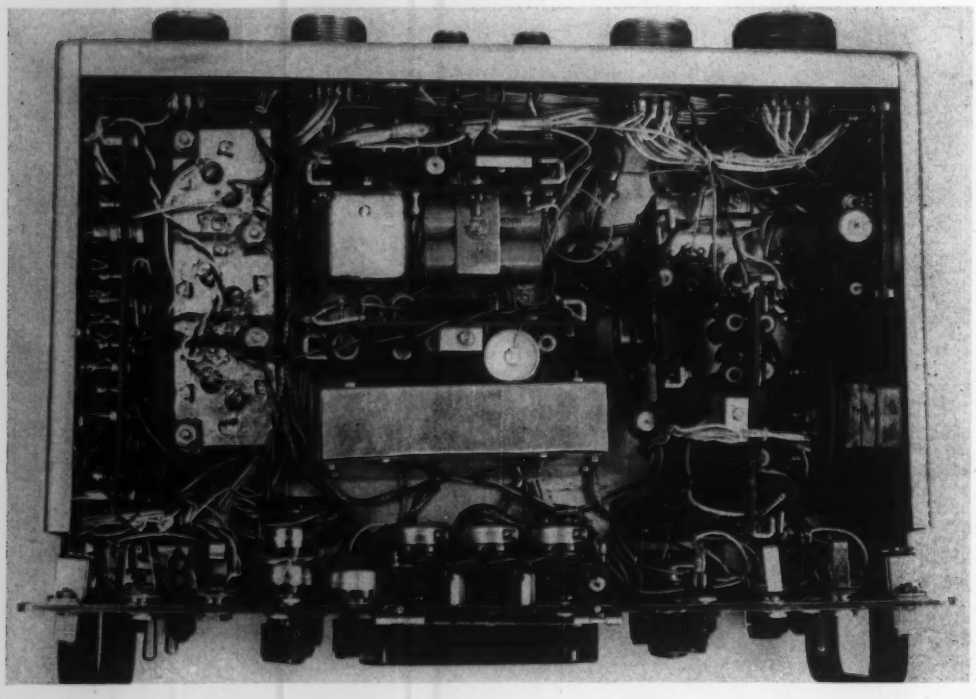
Translating friction ring amplifies force for sensitive positioning control. In a design developed by American Meter Co., a ring is engaged on its ID by a driving roller and on its OD by a pressure roller. Motion is transmitted between members by frictional engagement. As input motion is supplied to a pivoted control yoke, the ring is tilted and moves laterally along the rollers. Action is similar to that of a lead screw. The lateral motion is imparted to a follower wheel and carriage which transmits the output force.



(a)

(b)

Fig. 1—Inside view reveals, *a*, planned cabling and, *b*, unplanned. (Photos, courtesy Vitro Laboratories.)



Cable Design for Wired Equipment

FRANK WILLIAM WOOD Jr.
Engineer, Systems Development Dept.
Vitro Laboratories
Silver Spring, Md.

Routing and grouping of wires are an essential part of the production design of equipment. Besides neatness of appearance, advantages in assembly and maintenance can be gained by a little additional effort in the design stage.

PREFORMED cables and grouped leads can be designed with a minimum number of bends and branches. The simplified and efficient appearance that usually results is evident in the wiring comparison in Fig. 1. Performance and quality of the two units may be equally good, but service time would be a strike against the unplanned chassis.

Many advantages offset the additional design time required for planning preformed cables. They permit flexible, more efficient assembly methods. They minimize the chances of making wiring errors. A complete cable can be fabricated, tested, and coded before installation. Once it is placed in position on the chassis, the leads can be connected without the usual jumble of stray wires causing interference and confusion.

In some instances, precabling can include such components as tube sockets and connectors. When this method is used, bottom-mounting components must be selected as illustrated in Fig. 2.

Cable Lacing: Tying individual wires together into a cable provides a neat, easily handled assembly.

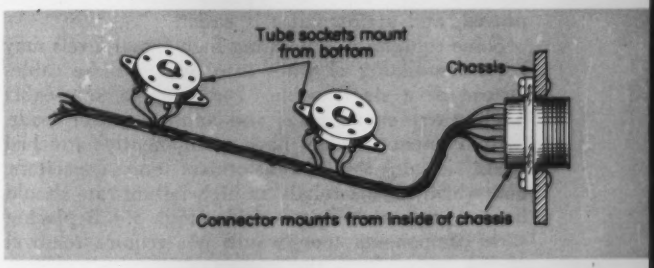


Fig. 2—Small parts can be connected in place during assembly of preformed cables.

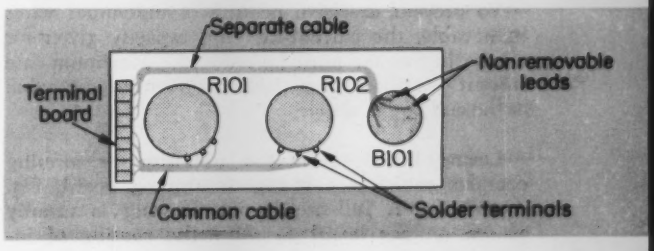


Fig. 3—Separate lacing of integral component leads facilitates replacement.

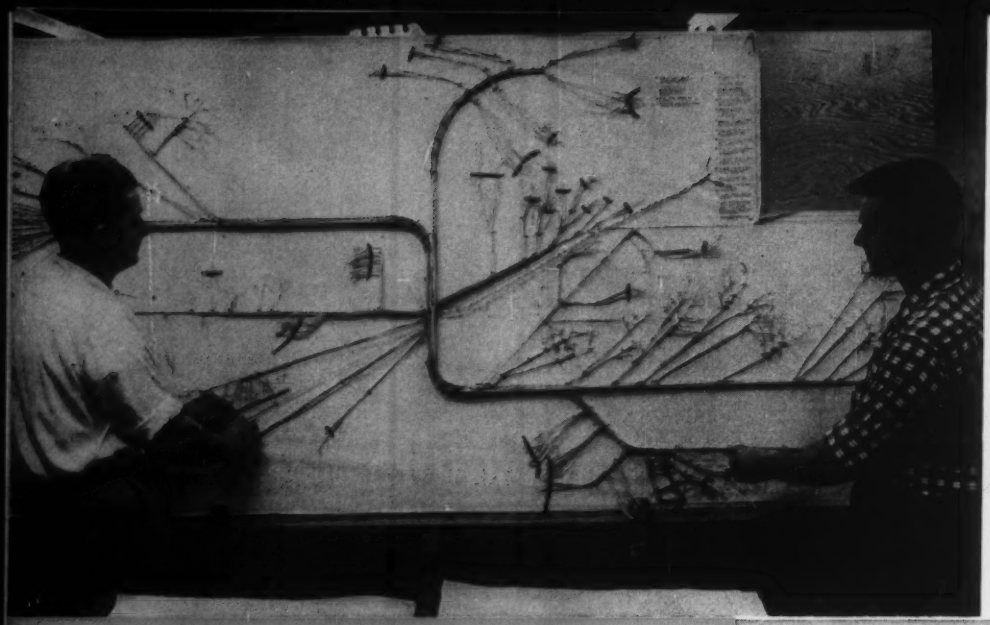


Fig. 4—Forming board uses spring coils to hold wire ends. (Photo, courtesy Vitro Laboratories.)

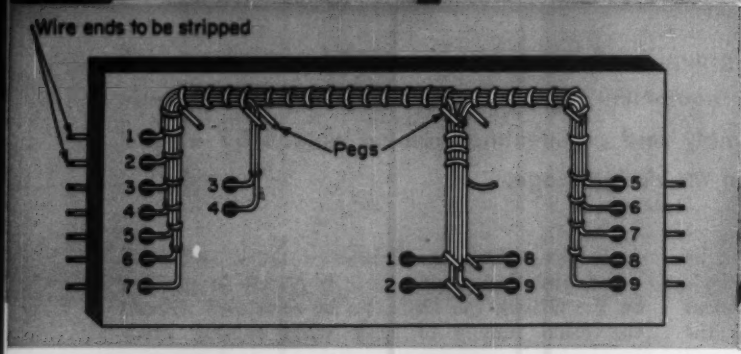


Fig. 5—Lacing board, or harness jig, has built-in limit for length of stripped ends.

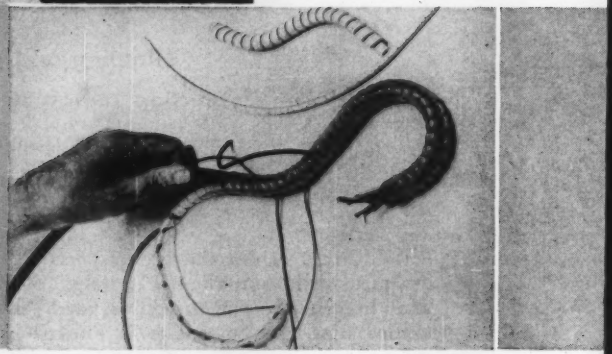


Fig. 6—Plastic spiral wrapping is convenient for both installation and maintenance. (Photo, courtesy M. M. Newman Co.)

Cables can be installed and supported more efficiently than individual wires. Reliability is improved, and maintenance is easier.

Some equipment generating high signal levels may require grouping of wires into two or more cables instead of a single cable. For example, one cable might carry signal leads and another power leads.

Components which have permanently attached leads, as do some transformers and capacitors, and which have a relatively high failure rate should have a separately laced cable, Fig. 3. Replacing such components then would not require removal of the lacing from the major cable.

To prevent excessive heating of individual wires in a cable, the current-carrying capacity given for a wire in free air must be reduced. Maximum safe current for wires in a cable is given in the table at the end of this article.

Lacing Board: Almost a necessity for forming complex cables is a lacing or forming board, Fig. 4 and 5. A full-size layout drawing is usually placed on the board to show the routing of individual wires. Another scheme is to mark the board with numbers and symbols to indicate wire sizes, color coding, routing, terminations, and wiring sequence.

To position wire runs, pegs or nails can be placed in a pattern that follows a pictorial wiring diagram. Conductor ends may be anchored to the board by wrapping them around pegs or nails, inserting them into holes in the board, or by forcing them between the coils of springs fastened to the board. Electrical checking devices or continuity testers can also be mounted on the forming board.

Lacing Materials: Advantages and disadvantages of some of the different lacing materials and methods are:

Electrical Tape: Spiral wrapping of cables is generally unsatisfactory because the tape tends to unravel under flexure and temperature changes. It is also inconvenient when maintenance requires access to individual wires.

Twine: Wax-impregnated twine has found general use, but nylon twine is now preferred. Twine

Cable Design Suggestions

1. Use preformed cables when possible.
2. Include minor parts in external assembly of preformed cables if convenient.
3. Derate capacities to prevent overheating.
4. Color-code leads for easier installation and maintenance.
5. Support cables at adequate intervals and locations.
6. Protect cables from sharp corners and projections.
7. Shield cables from hot components.
8. Route cables to avoid interference with component installation and maintenance.
9. Provide sufficient slack and a retraction device for cables used with pull-out chassis and hinged doors.

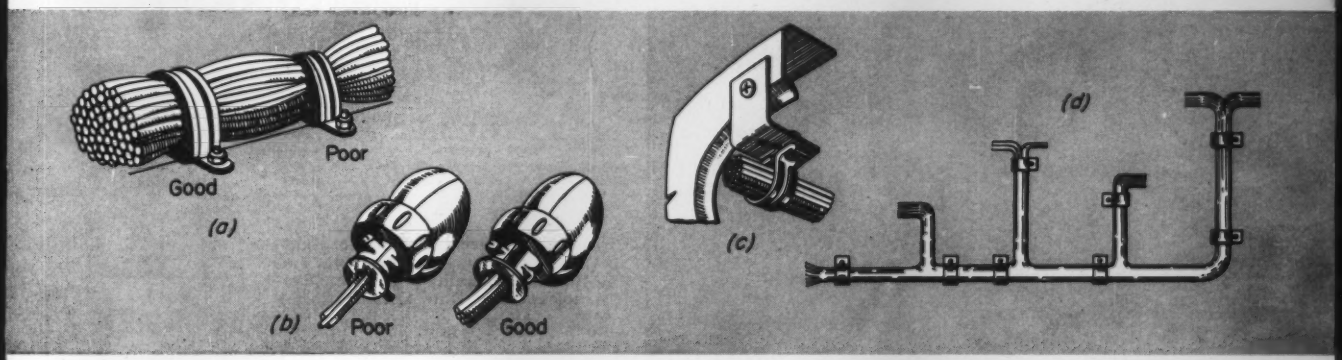


Fig. 7—Typical clamping installations illustrate unsatisfactory clamp choices in *a* and *b*.

does a satisfactory job, if properly applied, but the process is relatively slow. Also, maintenance is somewhat inconvenient.

Flexible Plastic Sleeving: For individual components that have attached leads, sleeving serves well. Main cables present servicing problems. One end of the cable must be free or loose so the sleeving can be removed for access to the individual wires. Disconnection of wires not ordinarily removed may be required.

Zipper Sleeving: Although it meets the minimum number of times required for installation and removal, zipper sleeving requires a special tool for both operations. The zipper slide is removed after the sleeving is closed and must be used again to reopen the sleeving.

Plastic Spiral: Easily installed, plastic spiral wrapping is also convenient for maintenance. Fig. 6 illustrates its adaptability. Any length of cable can be accommodated. Cable terminations need not be disturbed when the wrapping is installed or removed.

A variety of other devices are also commercially available. For example, individual "loops" that are adjustable and quickly applied exist in a variety of designs.

Cable Clamps: Once the cable is laced, it must be supported or tied down at adequate intervals to prevent damage that might result if the cable flexes under shock and vibration. Cable abrasion against a screw head, a sharp chassis corner, or a protruding terminal could cause extensive equipment damage and possibly endanger human life.

Long wires or cables should be securely anchored by clamps which distribute pressure over a wide area of the wire or cable surface. Clamps must not cut, pinch, or abrade the wires they support. The undersized clamp in Fig. 7*a* stresses both the conductor wire and the insulation. Correct clamp size centers the conductors and prevents pulling on terminals or connections.

Cable support is often required at plugs and receptacles. Loose wires shown in Fig. 7*b* will chafe under vibration and may break at the terminals.

Typical clamp installations are illustrated in

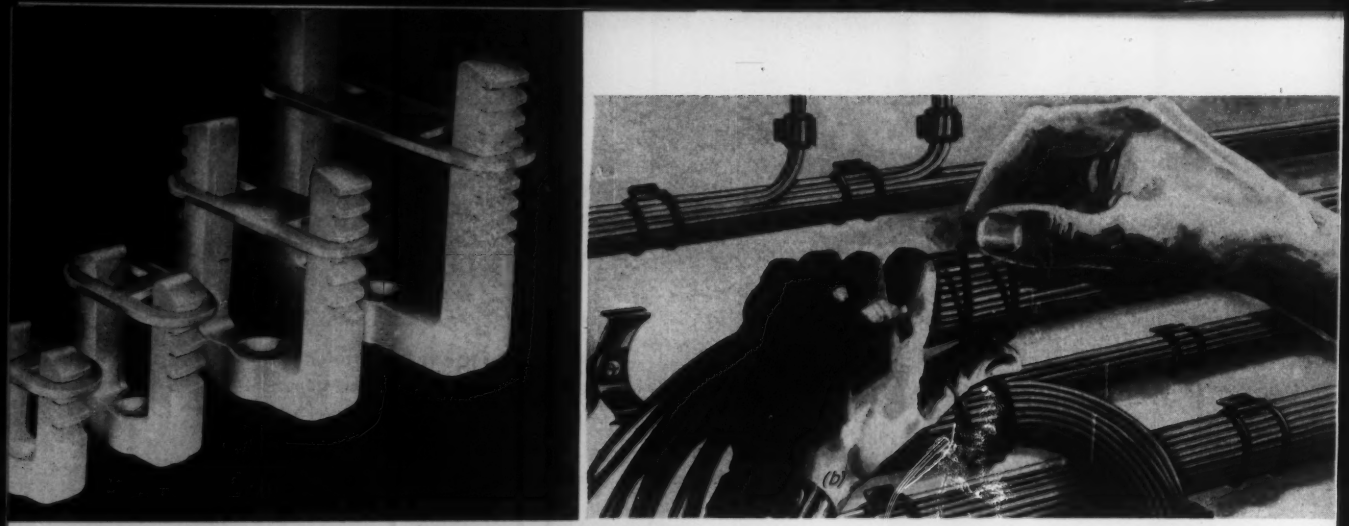


Fig. 8—Commercially available, these clamps feature adjustable and spring-loaded means for holding cables securely. (Photo *a*, courtesy Dakota Engineering Co. Inc.; photo *b*, courtesy Electrovert Inc.)

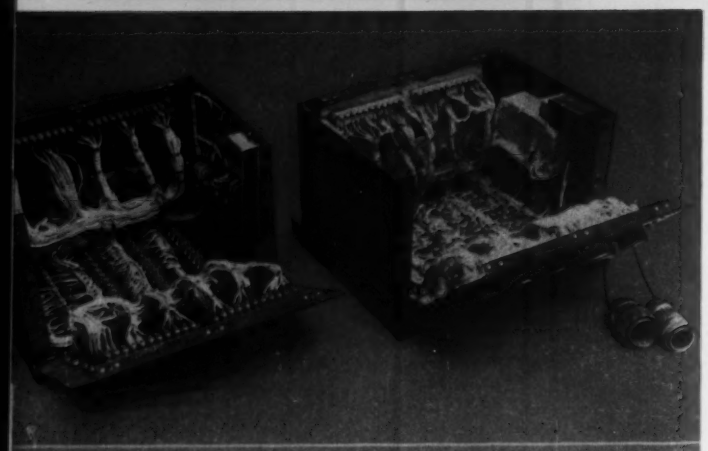


Fig. 9—Coating or potting of right-hand unit supports the cables and provides humidity protection. (Photo, courtesy Dow Corning Corp.)

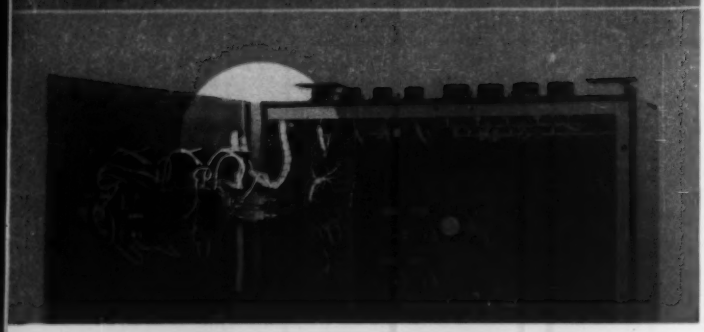


Fig. 10—Service loop in upper left cabinet corner has sufficient slack and is well supported. (Photo, courtesy Vitro Laboratories.)

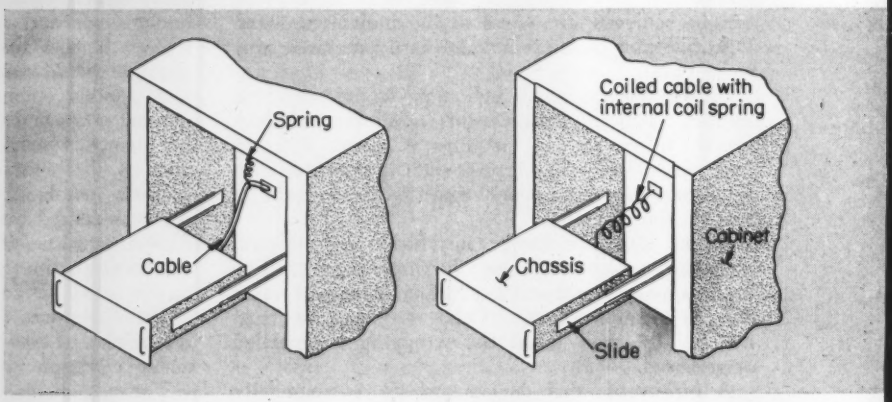


Fig. 11—Cable protection for swinging or sliding units can be provided by spring assemblies.

Fig. 7*c* and 7*d*. Harnesses are usually clamped at branches, bends, and intervals on long, straight runs. Two other types of clamps are shown in Fig. 8.

Fig. 9 shows a silicone rubber coating applied to the one unit as a cable and wire support. Humidity protection is also provided.

Service Loops: When cable connections are maintained between stationary equipment and sliding chassis or hinged doors, service loops are required to permit movement. Cables should be clamped at the last point of contact on both the chassis or door and the cabinet, Fig. 10.

The service loop should have a return feature to prevent damage and interference when sliding or removable chassis are replaced in the cabinet. Fig. 11 shows two methods for recoiling the cable.

Over-all cable planning is typified in the complex unit in Fig. 12 where component placement and maintenance were considered throughout the design. Service loops are required for the hinged door and the swing-out panels in the bottom section.

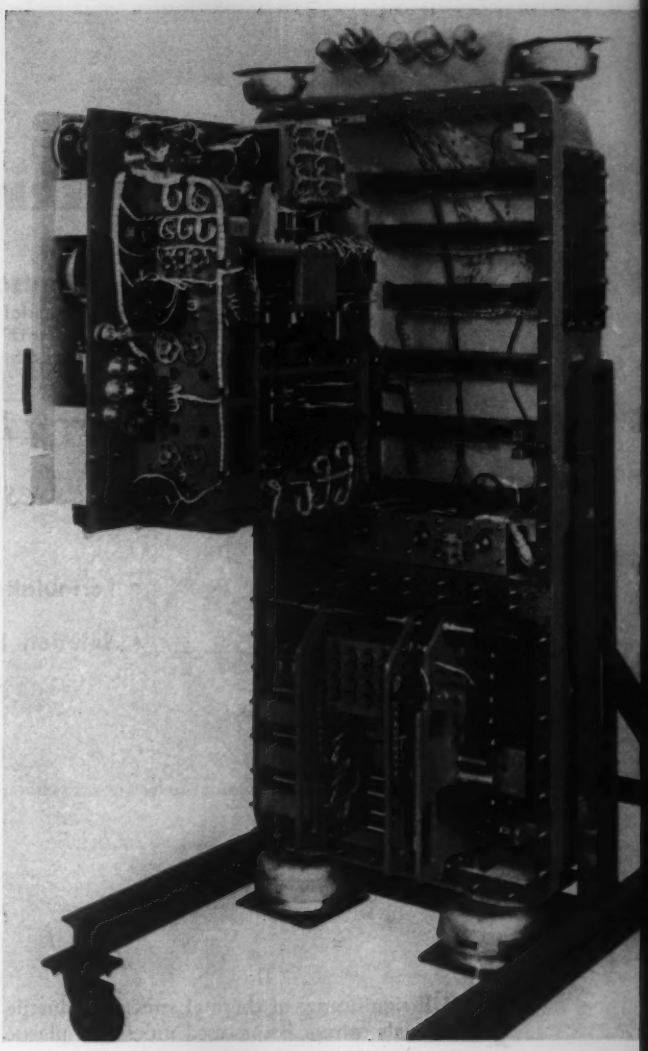


Fig. 12—Because of proper cabling and routing, function is clear and servicing is convenient in this large unit. (Photo, courtesy Vitro Laboratories.)

Current Capacity of Cables

Cable Size		Continuous Duty Current (amp)	
Aluminum	Copper	Single Cable in Free Air	Cables in Conduit or Bundles
	AN-22	...	5
	AN-20	11	7.5
	AN-18	16	10
	AN-16	22	13
	AN-14	32	17
	AN-12	41	23
	AN-10	55	33
	AN-8	73	46
	AN-6	101	60
	AN-4	135	80
	AN-2	181	100
	AN-1	211	125
	AN-0	245	150
	AN-00	283	175
	AN-000	328	200
	AN-0000	380	225
AL-8		60	36
AL-6		83	50
AL-4		108	66
AL-2		152	90
AL-1		174	105
AL-0		202	123
AL-00		235	145
AL-000		266	162
AL-0000		303	190

Current ratings for cables in bundles are based upon 15 or more cables carrying no more than 20 per cent of the total carrying capacity of the bundle. In smaller bundles the allowable percentage of total current may be increased as the bundle approaches the single-cable condition.

—From military specification MIL-W-5088, par. 3.5.2.1.2.

Military Specification References

Cable Assemblies
MIL-C-3885

Clamps
MIL STD 242; MIL-I-983, par. 3.8.10.3.3; MIL-E-5400, par. 3.1.35.1; MIL-E-16400, par. 3.3.13.1.

Color Coding
MIL-E-16400, par. 3.9.11.

General Design and Installation
BUORD OP2230, ch 7.

Grommets
MIL-I-983, par. 3.8.10.3.7; MIL-E-5400, par. 3.1.35.5; AN931.

Installation
MIL-W-8160.

Lacing
MIL-T-713; MIL-I-983, par. 3.8.10.3.3; MIL-E-5400, par. 3.1.35.6; MIL-C-572.

Maintenance
MIL-E-16400, par. 3.9.8.1.

Material
MIL-I-983, par. 3.8.10.1; MIL-W-76; MIL-C-915; MIL-C-2194; MIL-W-16878.

Reliability of Connector
MIL-E-5400, par. 3.1.35.4.

Service Loop
MIL-I-983, par. 3.8.10.3.5.

Slack
MIL-E-16400, par. 3.9.8.1.

Sleeving
MIL-I-7444; MIL-I-3190; MIL-E-5400, par. 3.1.34.1.

Terminals
MIL-E-5400; par. 3.1.26.3; MIL-E-16400, par. 3.3.49.1; MIL-E-19100, par. 3.3.48.1; MIL-T-5042.

Workmanship
MIL-I-983, par. 3.8.10.3.1.

THERMAL STRESSES IN DESIGN

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Part 11 — Stresses under Plastic Flow and Creep

- **Formulations**
- **Solution by Deformation Theory**

TRUE significance of thermal stresses in ductile materials cannot be assessed unless the plastic range is considered. Failure within the elastic range can occur by excessive distortion, buckling, or fatigue if a sufficiently large number of cycles is encountered. Fatigue failure at normal stress levels within the elastic range probably involves highly localized plastic flow. In general, however, fracture by thermal-stress fatigue involves plastic flow on a macroscopic level. In this article, methods of computing stress distribution will be discussed for applications where the yield point of the material is exceeded.

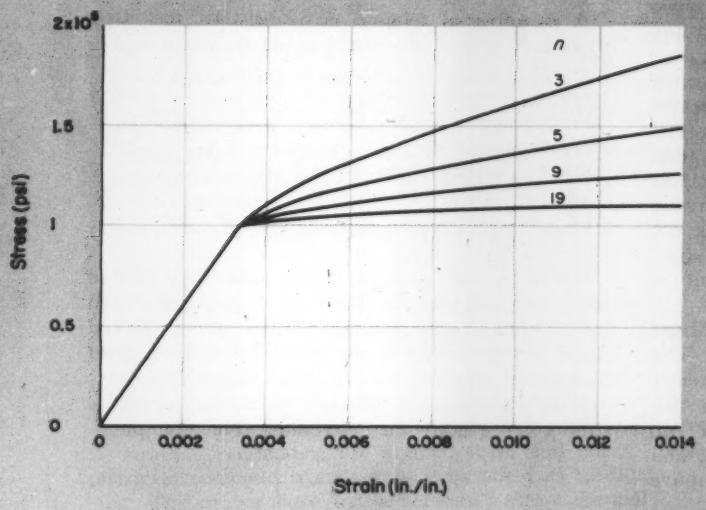
Formulations

In the equations for a plastic-flow solution, basic conditions of equilibrium and compatibility[6] are used, since these conditions relate to the mechanics and continuity of the body and are not contingent on elasticity. The only set of equations that differs from the elastic formulation is the stress-strain relation. For the plastic region, strain is not proportional to stress. Each strain component contains an elastic term, linearly related to the stress, and a plastic term, not linearly related. Because of the nonlinear differential equations that result, it is the nonlinear part of the component that complicates problem solution.

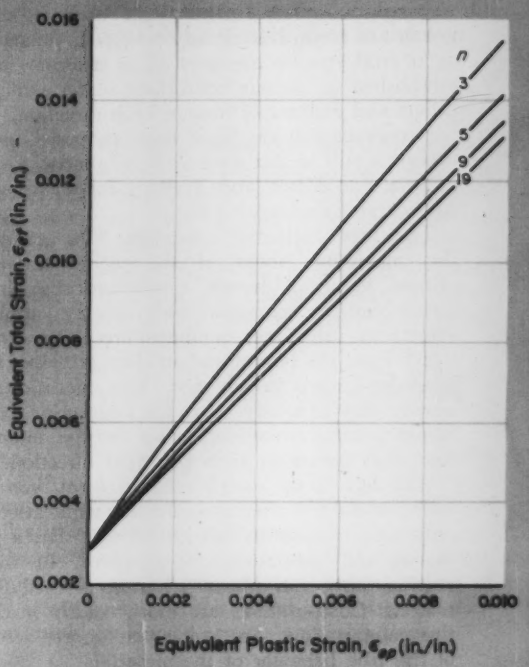
Deformation and Incremental Theories: The first decision faced in formulating a plastic-flow problem is whether the deformation theory or incremental theory should be used. Deformation theory establishes a relation between stresses and total strains. Hence, strains can be established directly if the stresses are known. One would think that the path by which a given stress distribution is reached presumably does not influence the strains. Elementary considerations, however, show that such an assumption cannot generally be correct. But if judgment is used, the region of inapplicability can in many cases readily be avoided. In fact, recent studies[11] have indicated that the restrictions on the applicability of the deformation theory are not as severe as once thought. On the other hand, this method has one big advantage: Less computation is needed.

[6]References are tabulated at end of article.

Fig. 68—Curves for graphically determining equivalent total and equivalent-plastic strains. Stress strain curves, *a*, for materials with same elastic-line and yield point but different plastic behavior and, *b*, plot of equivalent total and equivalent plastic strains for curves of *a*.



(a)



(b)

Nomenclature

E = Modulus of elasticity, psi
e = Strain, in. per in.
h = Height, in.
r = Radius, in.
T = Temperature, F
ΔT = Change in temperature, F
α = Coefficient of expansion, in./in./deg F
δ = Strain in. per in. (Determined from stress-strain curve for a given σ_e)
ε = Strain in. per in. (For small strains, $\varepsilon = e$. For large plastic strains, $\varepsilon = \ln(1 + e)$
μ = Poisson's ratio
ρ = Density, lb-sec^2/ft^4
σ = Stress, psi
ω = Angular velocity, rad per sec

Subscripts:

e = Equivalent
n = Station number
p = Plastic
r = Radial
t = Total
z = Third direction normal to r and θ
θ = Tangential

Incremental theory relates only the increment of strain to the increment of stress in a given stress state. To obtain the strain at a given stress state, the complete loading path must be considered by adding the increments of strain at each point to obtain the final strain. This method requires more computation. However, this procedure must be used if a reasonably correct solution is required. The method is feasible if high-speed computing machinery is available.

In this discussion, both the deformation and incremental theories are considered. If high-speed computing machinery is available, final calculations can be made by incremental theory. Deformation calculations are useful in preliminary design when time is limited, or when computing machinery is not available. Since the procedures for incremental theory are simple extensions of those for deformation theory, the latter is considered first here.

Flow Rules: When the plastic-flow theory to be used has been determined, the designer must decide which flow rule to use. For uniaxial stress, there is no ambiguity, since the stress-strain curve directly gives the information on the stress required

to cause initial plastic flow as well as the stresses required to cause further flow after a specified amount of strain has already occurred. When biaxial or triaxial stresses are present, a criterion must be established to include conditions under which flow occurs and amount of flow in each direction.

Numerous criteria have been proposed, and the theory is still in the state of development. Only two criteria, von Mises' and Tresca's, have received any considerable engineering use.

The Tresca criterion states that flow occurs when the maximum shear stress reaches a specified critical value. Although mathematically this criterion can be expressed very simply, application sometimes introduces complications. The directions which have the largest and smallest principal stresses must be known in advance. This condition is not always easy to satisfy. Also, for some principal stress combinations, ambiguity arises in the amount of flow that occurs in each principal direction.

Although more complicated in form, von Mises' criterion avoids complications in application. The only disadvantage in this criterion is that a greater amount of computation is involved. In this discussion, only von Mises' criterion is used for two reasons: Computations are more readily made, and the computations are somewhat more descriptive of the true behavior of the material.

Solution by Deformation Theory

When a material is subjected to the stress state, σ_r, σ_θ, σ_z, the strain components can be determined by application of the three basic relations:

1. Plastic shear strains are proportional to the shear stresses:

$$\frac{\varepsilon_{r,p} - \varepsilon_{\theta,p}}{\sigma_r - \sigma_\theta} = \frac{\varepsilon_{r,p} - \varepsilon_{z,p}}{\sigma_r - \sigma_z} = \frac{\varepsilon_{\theta,p} - \varepsilon_{z,p}}{\sigma_\theta - \sigma_z} = K_2 \quad (72)$$

2. Volume change due to the plastic flow is zero:

$$\varepsilon_{r,p} + \varepsilon_{\theta,p} + \varepsilon_{z,p} = 0 \quad (73)$$

3. A universal relation exists between the effective stress σ_e and the effective plastic strain $\varepsilon_{e,p}$:

$$\sigma_e \equiv \frac{[(\sigma_r - \sigma_\theta)^2 + (\sigma_r - \sigma_z)^2 + (\sigma_\theta - \sigma_z)^2]^{1/2}}{(2)^{1/2}} \quad (74)$$

$$\varepsilon_{e,p} = \frac{\sqrt{2}}{3}\left\{[(\varepsilon_{r,p} - \varepsilon_{\theta,p})^2 + (\varepsilon_{r,p} - \varepsilon_{z,p})^2 + (\varepsilon_{\theta,p} - \varepsilon_{z,p})^2]\right\}^{1/2} \quad (75)$$

Terms σ_e and $\varepsilon_{e,p}$ are so defined that they become stress and strain in the direction of the applied load for uniaxial stress. Since the relation between σ_e and $\varepsilon_{e,p}$ is universal, the stress-strain curve determined in uniaxial tension constitutes this relation.

From Equations 72 through 75, individual plastic strains can readily be determined. For example,

$$\varepsilon_{r,p} = \frac{\varepsilon_{e,p}}{\sigma_e}\left[\sigma_r - \frac{1}{2}(\sigma_\theta + \sigma_z)\right] \quad (76)$$

For plane stress, $\sigma_z = 0$. Hence,

$$\varepsilon_{r,p} = \frac{\varepsilon_{e,p}}{\sigma_e}\left(\sigma_r - \frac{1}{2}\sigma_\theta\right) \quad (77)$$

Corresponding expressions can be obtained for $\varepsilon_{\theta,p}$

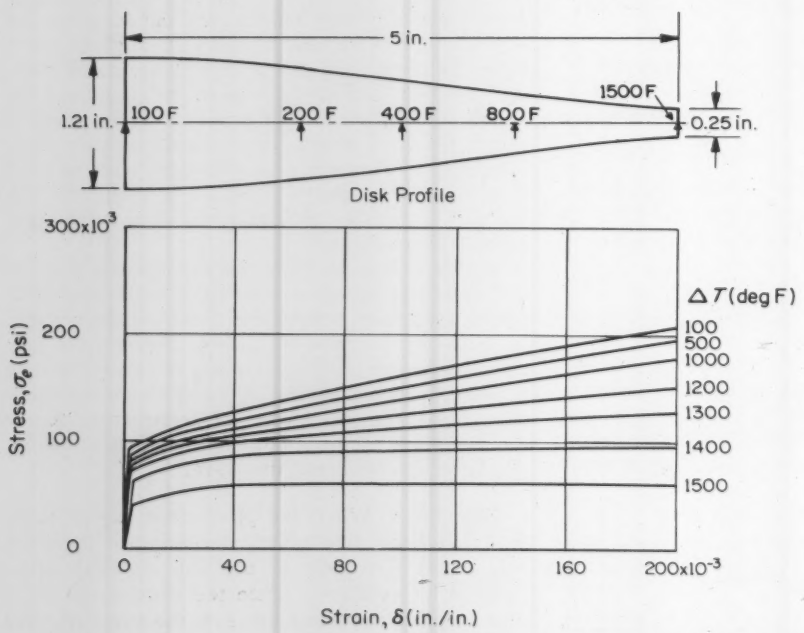


Fig. 69 — Disc profile, temperature distribution, and stress-strain curves at various temperatures used in Table 1.

and $\varepsilon_{z,p}$. The total radial strain becomes

$$\varepsilon_r = \frac{\sigma_r - \mu\sigma_\theta}{E} + \alpha T + \frac{\varepsilon_{e,p}}{\sigma_e}\left(\sigma_r - \frac{1}{2}\sigma_\theta\right) \quad (78)$$

A corresponding expression can be written for ε_θ.

These equations constitute the basic flow rules associated with von Mises' theory. The equations can be solved for stress in terms of the total and plastic strains. For example,

$$\sigma_r = \frac{E}{1-\mu^2}\left[\varepsilon_r - \mu\varepsilon_\theta - (\varepsilon_{r,p} + \mu\varepsilon_{\theta,p}) - (1+\mu)\alpha T\right] \quad .....(79)$$

A similar expression can be developed for σ_θ. In some applications, it is desirable to compute total and plastic strains separately. Hence Equation 79, which represents the stress in terms of both types of strains, becomes especially useful.

Total Strain Relationships: Equation 78 is convenient for determining the components of strains when components of stress are known. It is only necessary to determine σ_e from the stress component, establish $\varepsilon_{e,p}$ from the stress-strain curve for the known value of σ_e, and calculate ε_r and ε_θ from Equation 78. However, if the components of total strain ε_r, ε_θ, and ε_z are known, stress and plastic-strain components cannot be determined as readily.

The strains must first be separated into a thermal expansion, an elastic component, and a plastic component. Trial and error can be used, but the concept of equivalent total strain, $\varepsilon_{e,t}$[12] can be used instead. By analogy to Equation 75,

$$\varepsilon_{e,t} = \frac{\{2[(\varepsilon_r - \varepsilon_\theta)^2 + (\varepsilon_r - \varepsilon_z)^2 + (\varepsilon_\theta - \varepsilon_z)]\}^{1/2}}{3} \quad (80)$$

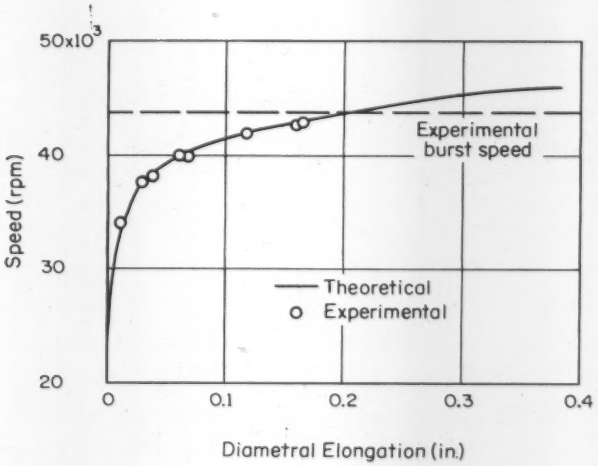


Fig. 70—Comparison of computed and experimental diametral elongation in disc subjected to a temperature gradient.

where ε_r, ε_θ, and ε_z are total elastic, thermal, and plastic strains, which are presumably specified. Once the equivalent total strain has been computed, the equivalent plastic strain can be determined from

$$\varepsilon_{e,t} = \varepsilon_{e,p} + \frac{2(1+\mu)\sigma_e}{3E} \quad (81)$$

where σ_e = equivalent stress corresponding to total-strain state ε_r, ε_θ, ε_z, or to plastic strain $\varepsilon_{e,p}$. The relation between $\varepsilon_{e,p}$ and σ_e is contained in the uniaxial stress-strain curve. Hence, for any selected value of $\varepsilon_{e,p}$, the value of σ_e can be determined. Thus, Equation 81 represents a direct relationship between $\varepsilon_{e,t}$ and $\varepsilon_{e,p}$, and the values can be determined graphically, Fig. 68*b*, from the stress-strain curve, Fig. 68*a*.

Once $\varepsilon_{e,t}$ and $\varepsilon_{e,p}$ have been determined, the components of plastic strain can be determined from

$$\varepsilon_{r,p} = \frac{\varepsilon_{e,p}(2\varepsilon_r - \varepsilon_\theta - \varepsilon_z)}{3\varepsilon_{e,t}} \quad (82)$$

Components $\varepsilon_{\theta,p}$ and $\varepsilon_{z,p}$ can be determined from cyclically symmetrical equations.

The foregoing method, in which the plastic strain components are determined from known values of total strain components is useful in solving thermal-stress problems by successive approximations.

Point-by-Point Solution: Solution of plastic-flow problems involves the same equilibrium and compatibility equations as elasticity problems. However, these equations must be combined with nonlinear stress-strain relations instead of the linear Hooke's law. In many applications, however, resulting equations are solved in an identical manner, except that a certain amount of systematic trial-and-error manipulation is required.

An example of a general approach,[13] ideally suited to one-dimensional problems, is the case of a disc with a radially symmetrical temperature distribution. Stresses and strains depend only on radius. There is no requirement, however, that the stress distribution be one-directional. Thus both radial and tangential stresses and strains must be considered.

Imposed conditions on the disc are of the boundary-value type, i.e., some conditions are known at the center and some are known at the rim. If the disc is solid, it is known that the radial and tangential stresses at the center are equal. If there is a central hole, the radial stress is usually zero at the inside bore, unless there is a forced fit or other internal loading.

At the rim, the radial stress is zero if there is no blade loading, or the radial stress has a known value if there is centrifugal loading due to blades. Because known conditions are divided between two boundaries, an additional condition at one of the boundaries must be assumed. Validity of the assumption is checked by determining its consequence at the other boundary.

Once the stresses are known at the center of the solid disc, finite-differences are used to proceed radially outward and determine the stresses at all radii, in-

cluding the rim. This solution gives the radial rim loading which will produce the assumed stresses at the center. Correctness of the assumed stresses is checked by comparing the required radial rim loading to the actual value. If the two do not agree, a second trial for center stress is made. Direction of modification is ascertained from the prior calculation. Several calculations and a plot of required versus actual radial rim-stress quickly leads to the correct center stress.

This procedure is illustrated in Table I for the disc shown in Fig. 69. The computation is made for the temperature distribution shown on the sketch of the disc profile and for a material having stress-strain curves at different temperatures as shown in the lower half of the figure. The rotative speed of the disc is 46,800 rpm, which corresponds to a value of $\rho\omega^2 = 19{,}000$ lb/ft.^{4} Columns 1 to 5 give radial locations of stations for finite difference solution, thickness h_n at each station, temperature, free thermal expansion at the temperature, and elastic modulus. Column 6 gives estimated value of $\sigma_{r,n}$.

The value of the stress at the center, $r = 0$, is initially an estimation based on the elastic-stress computation, with some allowance made for reduction in stress due to plastic flow. The stress-strain curve itself serves as a guide for this initial assumption of stress, since the stress must lie on the curve within reasonable limits of plastic flow. Although it is desirable to estimate the stress as closely as possible to the correct value, the first computation serves only to indicate the direction of improved assumption.

In the computation for the disc, the stress is taken as 111,000 psi, which corresponds to one or two per cent of the plastic flow at the corresponding temperature at the center. Column 7 gives $\sigma_{t,n}$, which for the center of the disc is the same as σ_r. Columns 8 to 13 give various stress and strain values which are computed for the disc center from the equations indicated in the table.

At the next station, $r_n = 0.5$, the first estimate of $\sigma_{r,n}$ is based on the value of $\sigma_{r,n}$ at $r = 0$, and is arbitrarily chosen as 109,500 psi. To check the correctness of this assumption, the value of $\sigma_{t,n}$ is computed from

$$\sigma_{t,n} = \frac{2r_n}{r_n - r_{n-1}}\sigma_{r,n} - \frac{2h_{n-1}\,r_{n-1}}{h_n(r_n - r_{n-1})}\sigma_{r,n-1} - \frac{h_{n-1}}{h_n}\sigma_{t,n-1} + \rho\omega^2\left[\frac{h_{n-1}}{h_n}r_{n-1}^2 + r_n^2\right] \qquad (83)$$

Once the radial and tangential stresses are known, the equivalent stress and the strain can be determined as shown in Columns 8 to 12. Correctness of the assumed value of σ_r at the 0.5-in. radius station can then be checked by determining the degree to which the compatibility equation is satisfied. In finite difference form, the compatibility equation is

$$e_{t,n} - \frac{r_{n-1}}{r_n}e_{t,n-1} - \frac{r_n - r_{n-1}}{2r_n}(e_{r,n} + e_{r,n-1}) = f(\sigma) = 0 \qquad (84)$$

Table 1—Plastic Stress Calculation For Small Strains

1 r_n (in.)	2 h_n (in.)	3 T_n (F)	4 $\alpha(\Delta T)_n$ (in./in.)	5 E_n (psi)	6 $\sigma_{r,n}$ (psi) (Estimate)	7 $\sigma_{t,n}$ (psi) (Equation 83)	8 $\sigma_{e,n}$ (psi) (Definition)	9 δ_n (in./in.) (Figure 69)	10 $\epsilon_{p,n} = \delta_n - \frac{\sigma_{e,n}}{E_n}$ (in./in.)	11 $\epsilon_{r,n}$ (in./in.) (Equation 78)	12 $\epsilon_{t,n}$ (in./in.) (Equation 78)	13 $f(\sigma)$ (in./in.) (Equation 84)
0	1.21	100	0.7×10^{-3}	30.7×10^{6}	111.0×10^{3}	111.0×10^{3}	111.0×10^{3}	15.0×10^{-3}	11.4×10^{-3}	8.8×10^{-3}	8.8×10^{-3}	$-\times10^{-3}$
0.5	1.20	110	0.8	30.6	109.5	111.9	110.7	14.8	11.2	8.6	9.1	+0.4
					108.5	109.9	109.2	13.3	9.7	7.9	8.2	+0.2
					109.0	110.9	110.0	14.0	10.4	8.3	8.5	0
1.0	1.13	140	1.0	30.5	108.6	109.1	108.9	13.7	10.1	8.4	8.5	0
1.5	1.04	180	1.3	30.4	106.0	108.6	107.3	12.7	9.2	8.0	8.5	−0.1
2.0	0.93	260	1.9	30.1	101.8	105.7	103.8	11.0	7.6	7.6	8.3	±0.1
2.5	0.81	400	3.0	29.7	95.1	100.7	98.02	8.6	5.3	7.5	8.2	−0.1
3.0	0.69	570	4.4	29.2	84.9	94.5	90.08	5.5	2.4	7.2	8.1	−0.1
3.5	0.58	770	6.3	28.4	71.5	73.2	72.37	—	0	8.0	8.0	0
4.0	0.43	1000	8.6	27.2	49.8	5.0	47.50	—	0	10.4	8.2	0
4.5	0.32	1250	11.4	25.2	12.1	−66.3	73.10	3.0	0.1	12.9	8.5	+0.1
5.0	0.25	1500	14.4	21.0	−41.1	−48.4	45.20	8.4	6.2	10.9	8.9	−0.1

For computations, $\mu = 0.333$, and $\rho\omega^2 = 19{,}000$ lb/ft^4

For each assumed value of σ_r, the residual associated with the corresponding values of σ_r and σ_t are tabulated in Column 13. Several values of σ_r are assumed until the residual becomes zero. This procedure is followed at each station. In Table 1, only the values of σ_r which cause the residuals to approach zero are tabulated at the stations beyond $r = 0.5$.

At the conclusion of the computation, the value of σ_r at the rim is determined. This value corresponds to the assumed value of σ_r at the center. For the example, a radial compressive stress of 41,100 psi is required if the assumed value of σ_r = 111,000 psi at the center is to be induced. If the radial rim-stress is some other value, such as zero for a freely spinning rim without blade loading, then another value of σ_r at the center must be assumed and the computation repeated.

The direction of an improved assumption is indicated by the results of the prior computation. Since a compressive stress at the rim has the effect of decreasing the stress at the centers then the stress at the center must be greater than 111,000 psi if the compressive stress is absent.

For a disc with a free central hole, the first station is taken at the radius of the hole, radial stress is zero, and computations are made for several estimations of the tangential stress at the inside hole.

Where external loads or body forces exist, large strains can be induced. Then two additional factors must be considered: 1. Use of natural or logarithmic strain in place of conventional strain. 2. Dimensional changes in the body, so that all quantities refer to the body in the deformed state rather than conventional derivations which consider only initial dimensions. For example, if $e_{r,n}$ is the conventional elongation, the natural radial strain is

$$\epsilon_{r,n} = \ln [1 + e_{r,n} - \alpha(\Delta T)_n] \qquad (85)$$

In cases including larger strains, the elastic portion of the strains may be neglected.

To account for dimensional changes in a rotating symmetrical disc, a station which was at a radius r_n moves, after a conventional tangential strain $e_{t,n}$, to a new radius

$$R_n = r_n(1 + e_{t,n}) \qquad (86)$$

Similarly, a thickness that was initially h_n becomes, after radial and tangential strains of $e_{t,n}$ and $e_{r,n}$,

$$H_n = \frac{h_n}{(1 + e_{t,n})(1 + e_{r,n})} \qquad (87)$$

Fig. 70 shows a comparison between computed and experimental values for permanent stretch in a rotating disc subjected to temperature gradient.[14]

The next article in this series will discuss the determination of plastic stresses by successive approximations.

References

This article is the eleventh in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of Machine Design in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" .... June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" . August 7, 1958
4. "Causes of Fatigue in Ductile Materials" ..... August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" ..... January 22, 1959
7. "Exact and Approximate Solutions" ..... February 5, 1959
8. "Elastic Stresses by Energy Methods" ..... February 19, 1959
9. "Elastic Stress Solutions" ..... March 5, 1959
10. "Elastic Stresses by Minimizing Residuals" ..... March 19, 1959

Other references mentioned in this article are:

11. Bernard Budiansky—"A Reassessment of Deformation Theories of Plasticity," *Paper No. 58-A54, Journal Applied Mechanics*, 1958.
12. A. Mendelson and S. S. Manson—"Practical Solution of Plastic Deformation Problems in Elastic-Plastic Range," *NACA TN 4088*, September, 1957.
13. S. S. Manson—"Analysis of Rotating Disks of Arbitrary Contour and Radial Temperature Distribution in the Region of Plastic Deformation," Proclamation First National Congress of Applied Mechanics.
14. P. I. Wilterdink, A. G. Holmes, and S. S. Manson—"A Theoretical and Experimental Investigation of the Influence of Temperature Gradients on the Deformation and Burst Speeds of Rotating Disks," *NACA TN 2803*, 1952.

Tips and Techniques

Areas of Regular Polygons

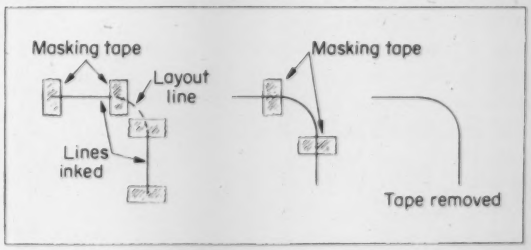
When one side of a regular polygon is given, the area can be found by multiplying the constant in the following table by the square of one side:

Number of Sides	Constant	Number of Sides	Constant
3	0.4330	12	11.1962
4	1.0	13	13.1858
5	1.7205	14	15.3348
6	2.5981	15	17.6424
7	3.6339	16	20.1094
8	4.8284	17	22.7414
9	6.1818	18	25.5208
10	7.6942	19	28.4654
11	9.3656	20	31.5688

—F. Murray, *Chicago, Ill.*

Neat Line Inking

Transparent tape can be placed at right angles to the layout line to eliminate thick or thin starts or stops, and line runover or runshort on inked drawings. The tape is placed at the point where the line starts, stops, or intersects another line. Starts

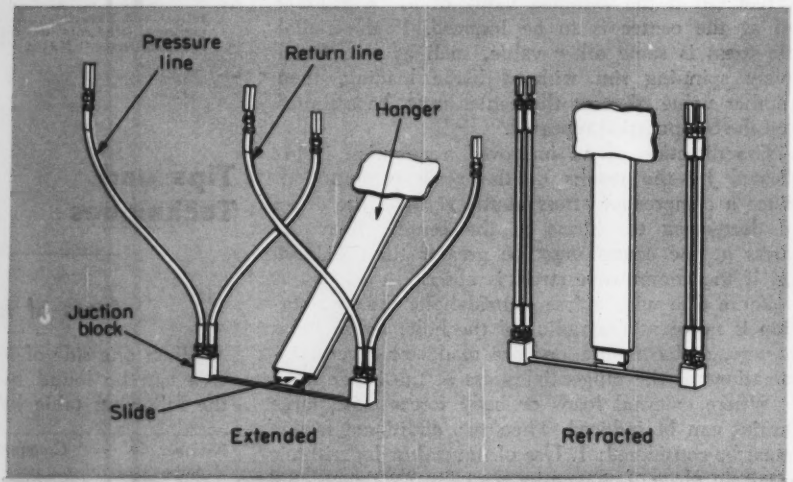


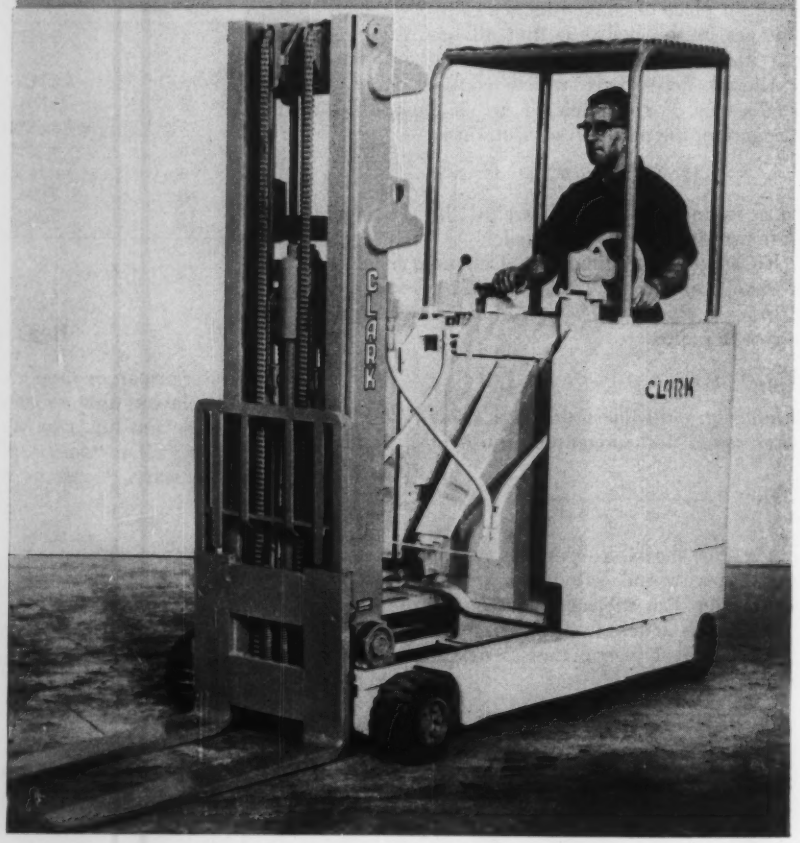
or stops are made on the tape which is later removed.—E. J. Kick, *Columbus-McKinnon Chain Corp., Tonawanda, N. Y.*

Swinging Hydraulic Junctions Solve Hose-Looping Problem

HOSE WEAR PRODUCED by fork extension and retraction is minimized in a new Clark industrial lift truck. Each loop of hose is replaced by two shorter pieces of hose connected to a common junction block. Mounted on each end of a bar on a swinging hanger assembly, the junction blocks allow the hose to make a 180-degree turn in little more space than the thickness of the hose.

A sliding section in the hanger permits it to vary in length during extension and retraction operations.

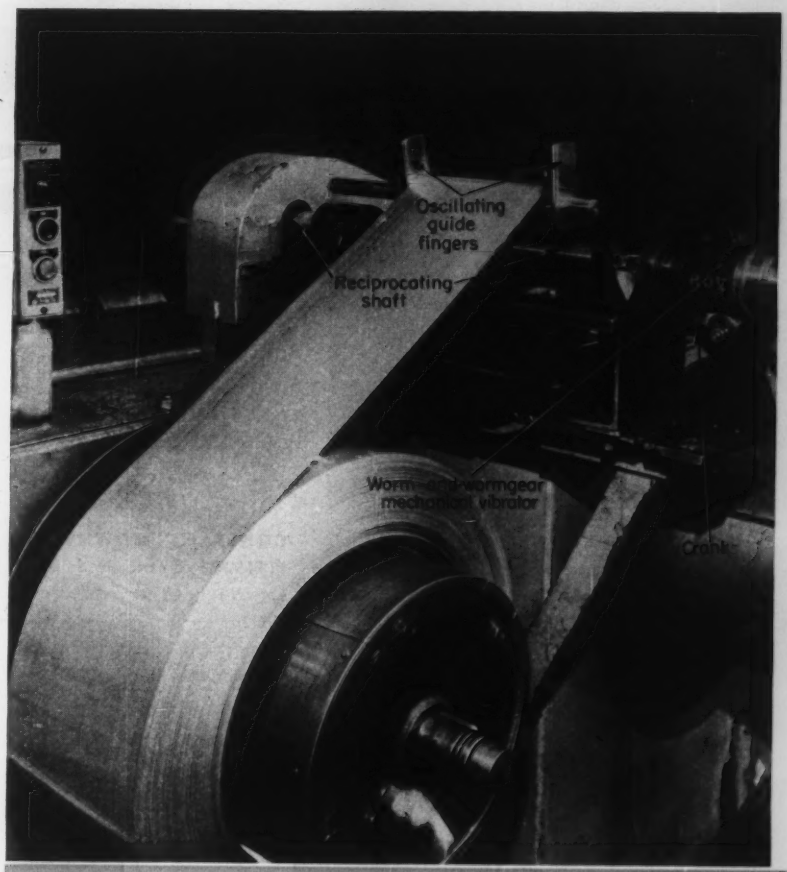




ROLLER-GRIP HANDLE controls braking, acceleration, and forward or reverse direction of vehicle travel. This same handle also controls lifting and lowering of fork.

The steering wheel is positioned in a vertical plane to prevent inadvertent turning by the operator from starts and stops.

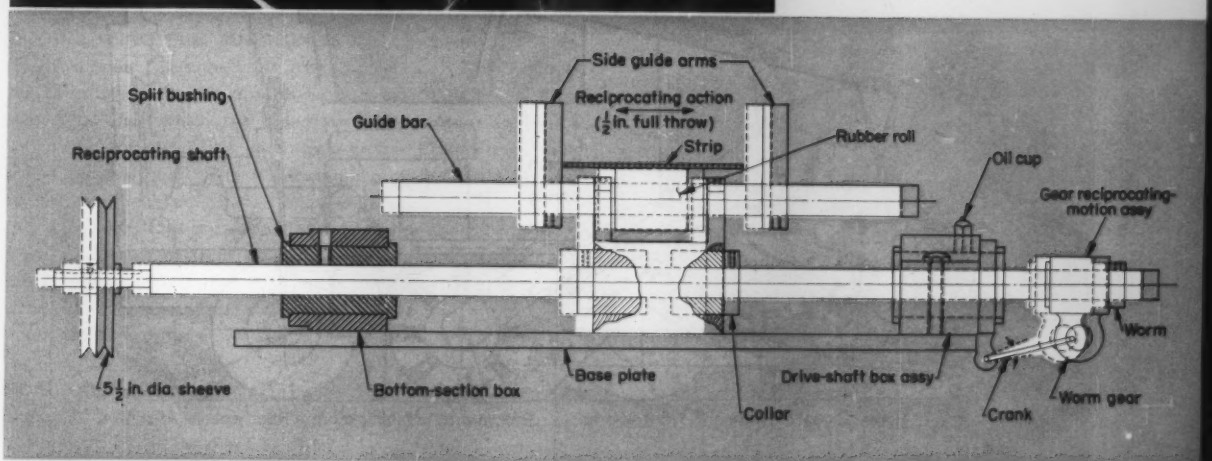
Vibrating Fingers Guide Thin Metal



MECHANICALLY VIBRATED BARS mounted on either side of a continuous wire strip serve as a simplified winding-guide control. As reported by Frank Buonomo, chief engineer, B. S. Roy & Son Co., Worcester, Mass. the system handles metal strips from 3 to 25 in. wide and 0.002 to 0.070 in. thick without damaging strip edges or surfaces.

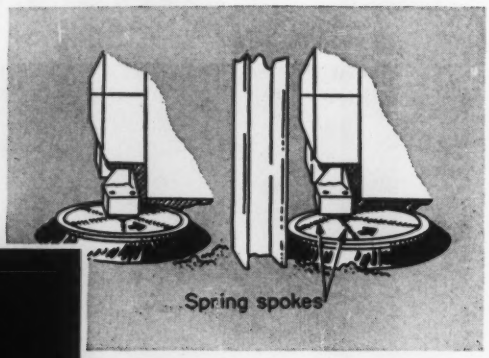
The guide-bar assembly and rotating shaft are oscillated over 150 times per minute by a ½-hp motor belt-connected to the shaft. Oscillating motion is produced in the shaft by a worm driving a worm gear connected to a crank.

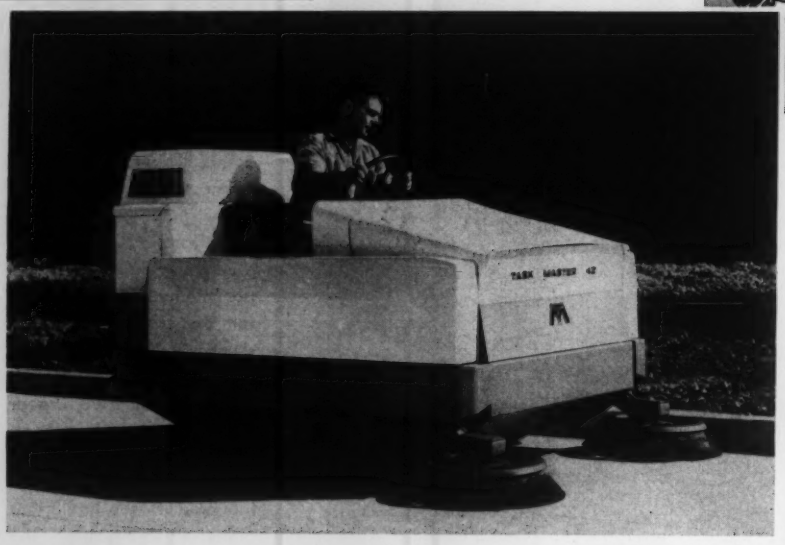
Rubber rolls of 80 to 90 Durometer hardness are mounted on the oscillating guide under the strip. The number of rolls used depends on the width of the strip.



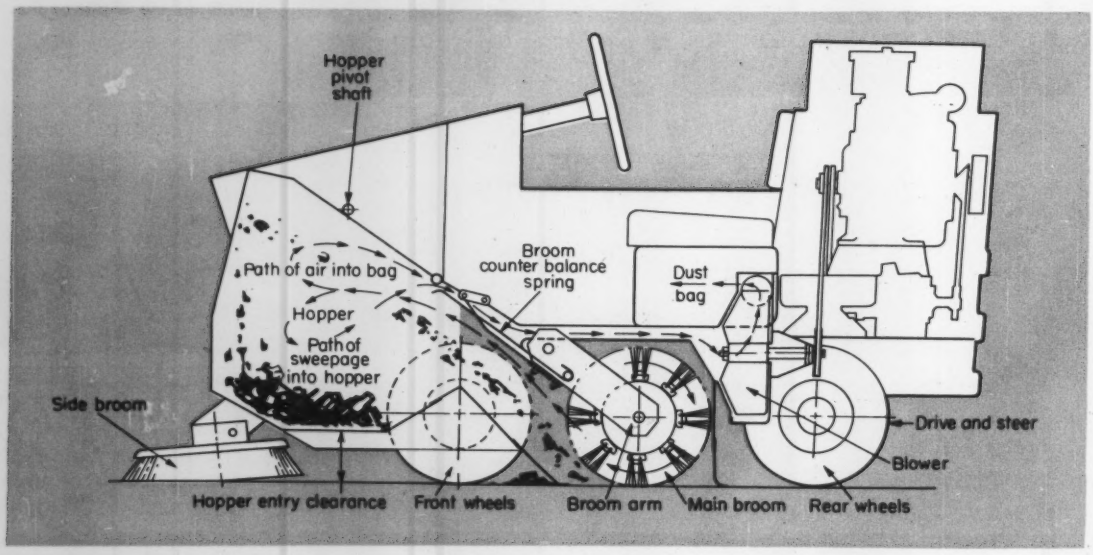
Brooms with Spring "Spokes"

MULTIPLE-SPRING SUSPENSION of the brush-strip plates in rotating side brooms simplify operation of new industrial power sweeper. These wire-spring "spokes" allow the side brooms to automatically adjust to obstacles during close-quarter sweeping. Brooms of this design can also absorb full impact when they collide with immovable objects, and they eliminate the need of a side-broom guard, such as a large rubber roller.

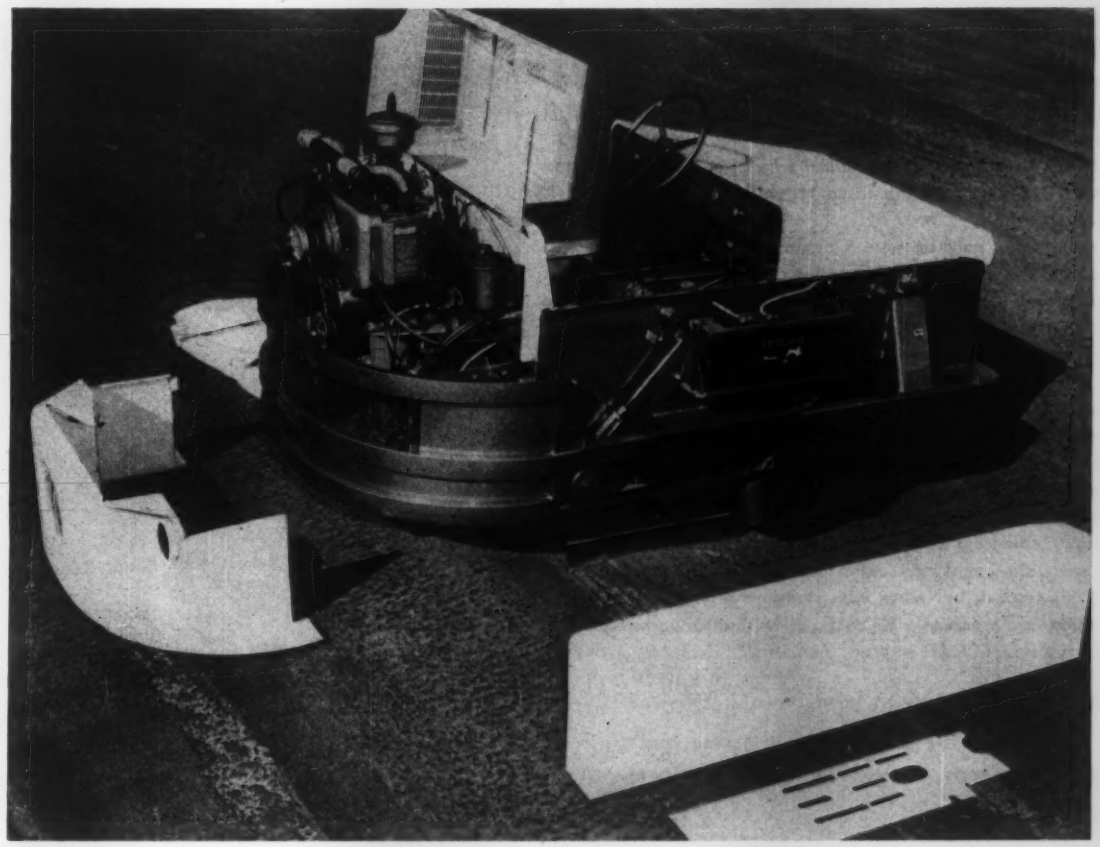




CONSTANT DOWNWARD PRESSURE is provided by a spring-loaded counterbalance system on the side and main brooms. Rubber-mounted dampeners stabilize contact pressure on main broom.



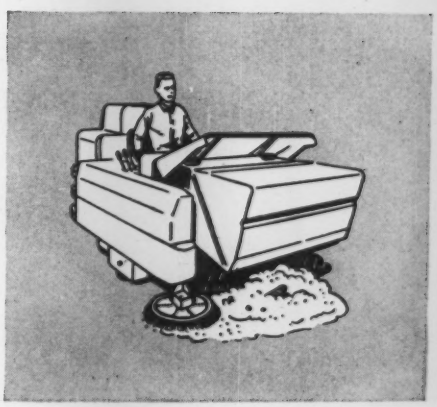
Permit Off-Center Rotation



GOOD STYLING PLUS RUGGEDNESS are combined in this deluxe sweeper. Designed by Task Master Inc., Azusa, Calif., the vehicle is built with a wrap-around fabricated channel and tubing bumper which are integrally welded to side plates.

An automatic clutch maintains proper broom and travel speed relationships. The transmission provides three forward speeds and reverse.

Elongated foot-control pedals permit the operator to move fully to the left or right to observe side brooms without losing control of the sweeper. The accelerator pedal is 15 in. wide. The brake pedal is 27 in. in width.



HOPPER DUMPING is accomplished in 10 sec with twin double-acting hydraulic cylinders. In the closed position, the hopper is sealed airtight by the cylinders.

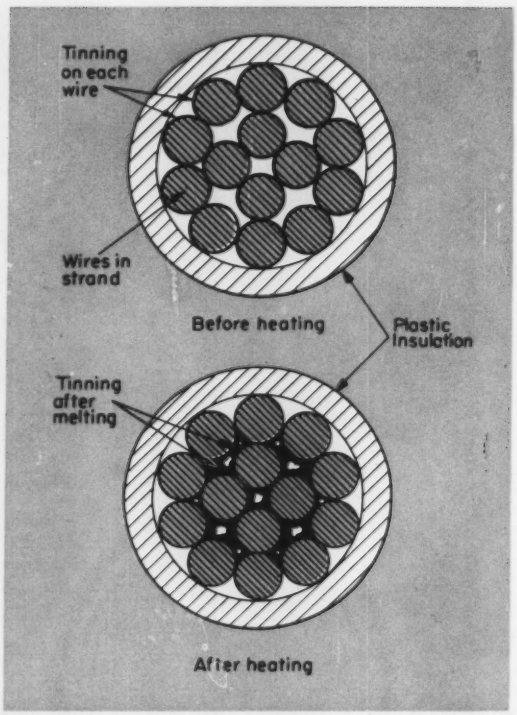
RF Heat Tins Wire Strand Before Insulation Is Stripped

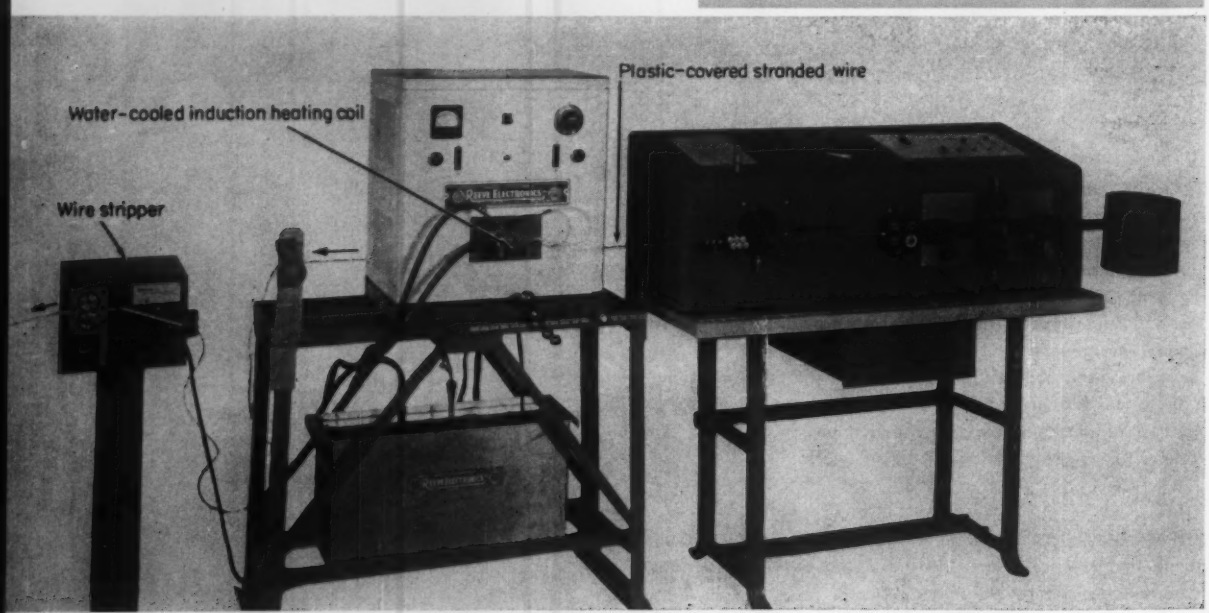
INDUCTION ENERGY MELTS the tin coating on individual wires in a strand at preselected cut-off points before the strand is cut and stripped. The technique eliminates the step of twisting and tinning stranded electrical wire after it is stripped and cut off. The strands are fused together but the insulation is left unaffected.

Stranded hook-up wire is automatically fed from a standard reel or spool through an induction-heating work coil of a machine designed by Reeve Electronics Inc., Chicago. The wire is then fed on to an automatic wire-measuring, cutting, and stripping machine.

The combination of the induction heating and stripping equipment is set up to automatically sense points along the wire where cuts and baring of the wire will occur. At these spots a short pulse of radio-frequency energy is applied as the wire travels to the stripper. The rf energy melts the tin coating on each individual wire in the strand, and the tin reflows, soldering that section of the strand into a solid bundle.

Double-tinned and extra-tinned wires are ideally suited for this process, but wires with standard tinning can be easily bonded in most cases. Silver-plated wire also works well with this system.





An Engineering Approach to HYDRAULIC LINES | No. 6

Selecting Hydraulic Connections

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HYDRAULIC systems are seldom fitted entirely with lines of the same type. Often pipe, hose, and tubing must transition from one to the other. Selecting the right fitting for these transitions is complicated by differences which exist between the various line types themselves. Size, thread type, and adaptability are a few variables which must be considered in selecting the most efficient fitting for the job.

This concluding article of a planned program on hydraulic lines presents information on the various types and sizes of fittings available, and discusses the factors which are essential in selecting and applying hydraulic connections.

Fittings consist of two essentially independent connection designs, one on each end. Each design provides mechanical and hydraulic linkage for a particular type of line or port entry. Therefore, several primary requirements must be considered in selecting a hydraulic fitting.

1. The efficiency of mechanical closure for a fitting usually determines its hydraulic performance. Hence, the mechanical bond should remain firm under vibration and outside abuse.
2. Fittings should provide leakproof connection under maximum pressures. However, this requirement varies somewhat depending upon the required cleanliness in the installation.
3. The ease with which lines can be assembled and the degree of fitting re-usability are factors which vary considerably with various types of fittings.

Standards

Fittings are available in a multitude of sizes, types, and materials. To insure that certain connections could be universally used, JIC Standards were set up. The following paragraphs, adapted from the JIC Standards, give recommended practices for line connections.

1. Piping between actuating and feed-control devices should be constructed to rigidly confine a minimum volume of fluid. The purpose is to maintain constant, controlled motion and restrict the effect of varying forces.
2. Solderless pipe connections such as flare, flare-

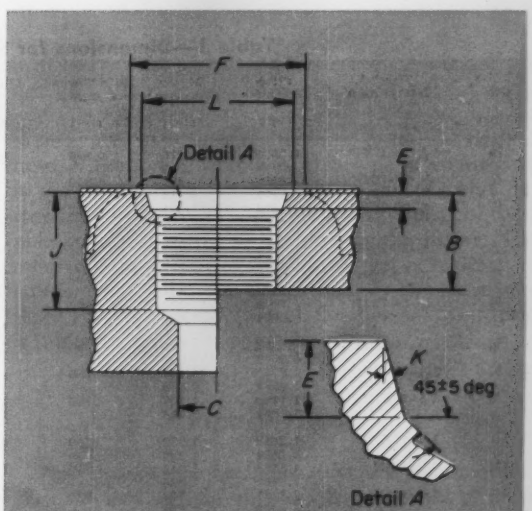

Fig. 1—SAE straight-thread O-ring port and flare type fitting.

less, self-flaring, and flange should be used.

3. Performance of any type fitting used should be equal to, or exceed, the requirements of MIL-F-5506.

4. All pipe threads should be Dryseal American (National) Standard Taper Pipe Threads (NPTF).

5. Fittings with straight threads and which incorporate pressure seals may be used in place of pipe-thread fittings.

6. All piping connections should be designed and installed to permit quick removal and reassembly by means of hand tools.

7. Only steel should be used as fitting material. Copper-alloy fittings should not be used with petroleum-base fluids. Fittings with restricted or stepped-up passages are not recommended.

8. Whenever practicable, each piping run should be integral and continuous from one piece of apparatus to another. Piping runs should be removable without dismantling equipment components and without bending or springing the tubing in a manner that would damage it.

9. When high or extra high-pressure piping is used, all connections should be welded to steel flanges, or connections should be used which are equal in performance and ease of assembly. Flanged connections should use sealing devices that seal with pressure.

Port Connections

A vast majority of hydraulic components used in system design have ports which are threaded or flanged. The type of port used depends upon the port connection and how easy it is to install, how often it must be removed, and how strong it must be. Hence, it is necessary to carefully select the proper port connection to prevent line failure.

Tapered Pipe Thread Ports: Until recently, Dryseal tapered pipe threads were almost exclusively used for port connections. This method provides reasonably leakproof connections up to pressures of about 1000 psi and is still used on a limited basis. The inherent disadvantage of this port is that the sealing is performed by a destructive interference fit. This type of fit depends on good tolerances and workmanship, and offers very limited re-usability because of the tightening mechanism. Other disadvantages include poor directional adjustment of angular outlet fittings and dependency on high tightening torques. While insufficient tightening results in leakage and poor vibration control, overtightening can produce cracks in the port housings which are usually cast.

SAE O-Ring Ports: The disadvantages of the pipe threads became apparent when pressures in hydraulic systems increased. One early development to overcome these disadvantages was the AN port design which used a straight thread with an O-ring as the sealing element. The SAE O-ring port design is an improved version of this original development.

This design is widely accepted and is approved by JIC. Fig. 1 shows a typical O-ring boss and fitting while Table 1 gives boss dimensions for this type. The outstanding advantages of this port connection are: 1. Depth of thread required in component body is less than for pipe-threaded connections, and thinner walls can be used. 2. Torque to produce a leakproof connection is substantially smaller than for pipe threads. Danger of overtorque with all subsequent disadvantages is eliminated. 3.

Table 1—Dimensions for SAE Straight-Thread O-Ring Ports

Tube OD (in.)	Thread Description	Pitch Diameter (in.)	Minor Diameter (in.)	Min Thread Depth *B* (in.)	Diameter *C* (in. min)	Diameter *D* (in.) +.005, −.000	Height *E* (in.) +.015, −.000	Diameter *F* (in. min)	Height *J* (in. min)	Angle *K* (deg) ±1 deg	Diameter *L* (in. min)
1/8	5/16-24-UNF	0.2902 .2854	0.275 .268	0.390	0.062	0.358	0.074	0.520	0.468	12	0.438
3/16	3/8-24-UNF	.3528 .3479	.337 .330	.390	.125	.421	.074	.592	.468	12	.500
1/4	7/16-20-UNF	.4104 .4050	.391 .384	.454	.172	.487	.093	.664	.547	12	.563
5/16	1/2-20-UNF	.4731 .4675	.453 .446	.454	.234	.550	.093	.736	.547	12	.625
3/8	5/8-18-UNF	.5323 .5264	.510 .503	.500	.297	.616	.097	0.809	.609	12	.688
1/2	3/4-16-UNF	.7159 .7094	.690 .683	.562	.391	.811	.100	1.025	.688	15	0.875
5/8	7/8-14-UNF	.8356 0.8286	.806 .798	.656	.484	0.942	.100	1.170	.781	15	1.000
3/4	1 1/16-12-UN	1.0158 1.0084	.982 0.973	.750	.609	1.148	.130	1.458	.906	15	1.250
7/8	1 3/16-12-UN	1.1409 1.1334	1.107 1.098	.750	.719	1.273	.130	1.604	.906	15	1.375
1	1 5/16-12-UN	1.2659 1.2584	1.232 1.223	.750	0.844	1.398	.130	1.746	.906	15	1.500
1 1/4	1 5/8-12-N	1.5785 1.5709	1.544 1.535	.750	1.078	1.713	.132	2.180	.906	15	1.875
1 1/2	1 7/8-12-N	1.8287 1.8209	1.794 1.785	.750	1.312	1.962	.132	2.466	.906	15	2.125
2	2 1/2-12-UN	2.4540 2.4459	2.419 2.410	0.750	1.781	2.587	0.132	3.192	0.906	15	2.750

All threads Class 2B

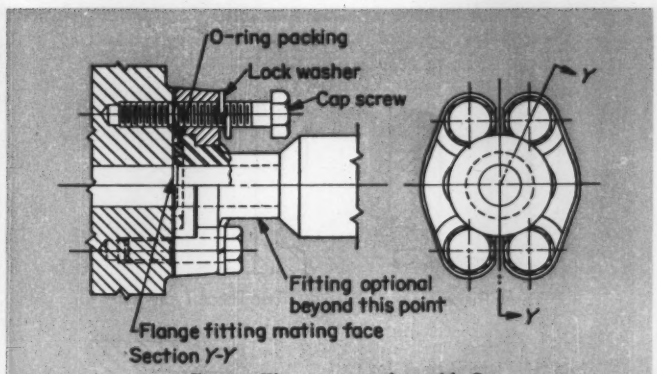

Fig. 2—Flange connection with O-ring used as sealing element.

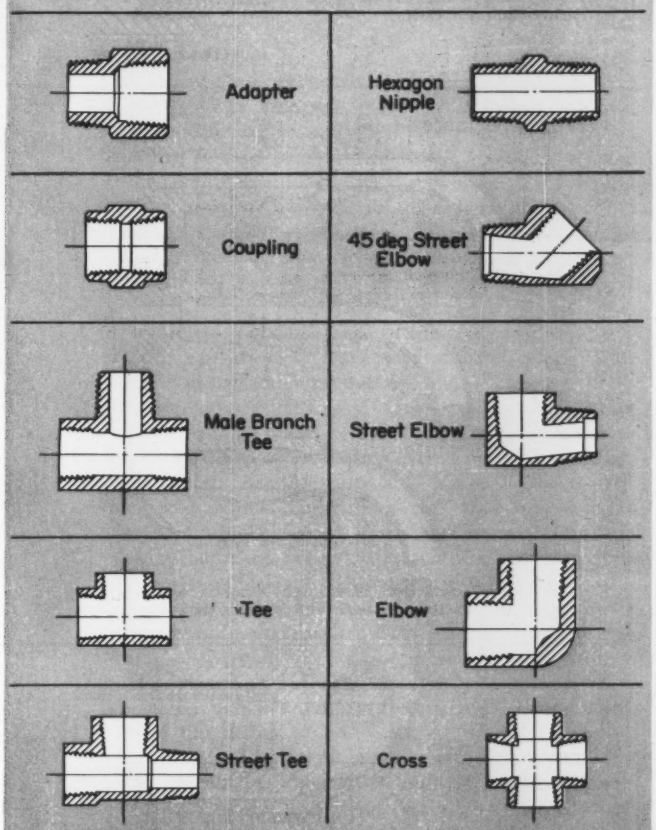

Fig. 3—Principal types of pipe fittings. All threads are tapered, preferably NPTF (Dryseal).

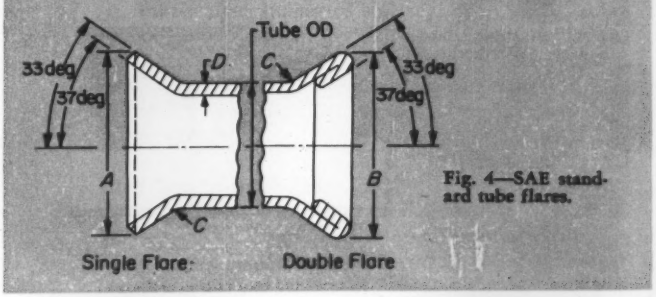

Fig. 4—SAE standard tube flares.

Number of reassemblies without deterioration of the joint quality is unlimited. 4. Directional positioning of angular outlet fittings is possible without impairing the sealing property. 5. Sealing effect is proportional to the system pressure, and leakproof connections can be obtained for most current system pressures.

Use of SAE straight-thread ports is rapidly increasing, although availability of components with these port types is limited.

Straight-Thread Ports with Metal Seals: SAE ports require a facing operation to secure proper positioning of the nut and require accurate machining of the O-ring groove. To eliminate these requirements, several new designs have been developed which achieve sealing with metal-to-metal contact.

Flange Connections: For large-size components and on some critical applications, flanged connections are preferred. Sealing in a flange joint is achieved with an O-ring compressed against a ground surface. Fig. 2 shows typical flange connection. O-ring carrying stems are welded to pipe or tubing, and are permanently or clamp-connected to hose. Vibration resistance of this type of connection is excellent, and re-usability is unlimited. Also, restrictions in passages are eliminated, since the port hole coincides with the opening in the fitting. The relatively large area of the port which is required to accommodate the four flange bolts is one disadvantage. For this reason, use of the flange-type fitting is preferred on larger components.

Table 2—Dimensions of Single and Double-Flare Tube Ends

Nominal Tube OD (in.)	Single Flare Diameter, A (in., max)	Single Flare Diameter, A (in., min)	Double Flare Diameter, B (in., max)	Double Flare Diameter, B (in., min)	Radius C (in.) ±0.01	Wall Thickness D (in. max)
⅛	0.224	0.214	0.224	0.214	0.032	0.035
3/16	.290	.280	.302	.292	.032	.035
¼	.359	.349	.359	.349	.032	.065
5/16	.421	.411	.421	.411	.032	.065
⅜	.484	.474	0.484	0.474	.046	.065
½	.656	.646	....	....	.062	.083
⅝	.731	.771	....	....	.062	.095
¾	0.937	0.927	....	....	.078	.109
⅞	1.062	1.052	....	....	.078	.109
1	1.187	1.172	....	....	.093	.120
1¼	1.500	1.485	....	....	.093	.120
1½	1.721	1.706	....	....	.109	.120
2	2.356	2.341	....	....	0.109	0.134

Pipe Fittings

Pipe fittings are available in many combinations of male and female threads. Some of the typical pipe fittings available are shown in Fig. 3. In general, pipe fittings are made of brass in small sizes for low and medium-pressure applications, cast iron in large sizes, and steel for high-pressure applica-

tions and when the system must conform to JIC Standards.

Tube Fittings

Tube fittings have at least one provision for attachment to hydraulic tubing. Hydraulic sealing action is achieved by flare, self-flaring, or flareless designs.

Flare Type: Fluid sealing in a flare fitting is accomplished by pressing the flared end of the tubing against the mating surface of the fitting. The JIC Standards specify that the angle of flare for the tubing should be 37 deg from the centerline, 74 deg included angle, and flare dimensions should be in accord with Army-Navy Design 10061. Table 2 gives dimensions for SAE standard flared tubing shown in Fig. 4.

The 37-deg flare has been adopted as standard by JIC and is included as an alternate in SAE Standards. The 45-deg flare is SAE standard and is used extensively by the automotive industry. Since JIC Standards require steel as the only permissible material for fittings, the 37-deg fittings are commercially available only in steel. However, the automotive industry is concerned primarily with low pressures. This makes it advantageous for the automotive industry to use the 45-deg brass fittings which are lower in price. The great majority of all hydraulic applications make use of the JIC-SAE 37-deg flare as standard for steel fittings. Comparisons between pipe, tube, and hose sizes, and fitting thread systems are given in Table 3.

Several types of flared fittings, Fig. 5, are available for use in connecting hydraulic tubing:

1. Single-piece nut fitting (two-piece assembly). Sealing pressure against flare is provided directly by nut which has a long neck for proper alignment with tubing. High torque necessary to get proper flare contact tends to twist tubing, and the frictional resistance between nut and flare may result in unequal distribution of the compression force acting over the flare area. The long nut also needs its full length of straight-run tubing before a bend can start.
2. Three-piece fitting assembly, also known as nut and sleeve type. Tightening force is supplied by a short nut, while actual sealing pressure is transmitted by a sleeve which can transfer only axial forces and absorbs the wiping friction generated by nut tightening. Since the nut is short, tubing bends can be placed much closer to the fitting than in the single-piece nut fitting.
3. Inverted flare type fitting with 45-deg flare. This fitting has the flare on the inside of the fitting body and the swivel piece is in the form of a male threaded part. The inverted flare fitting is used mainly in automotive applications where it permits closer bends than the regular SAE 45-deg flare fitting, Fig. 6. However this advantage is lessened by the increase in tube movement during disassembly.

Self-Flaring Types: These fittings do not require a special flaring operation and hence, the possi-

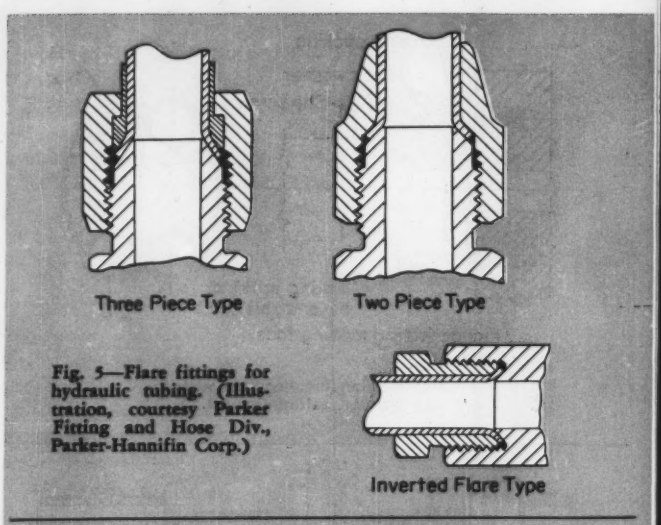

Fig. 5—Flare fittings for hydraulic tubing. (Illustration, courtesy Parker Fitting and Hose Div., Parker-Hannifin Corp.)

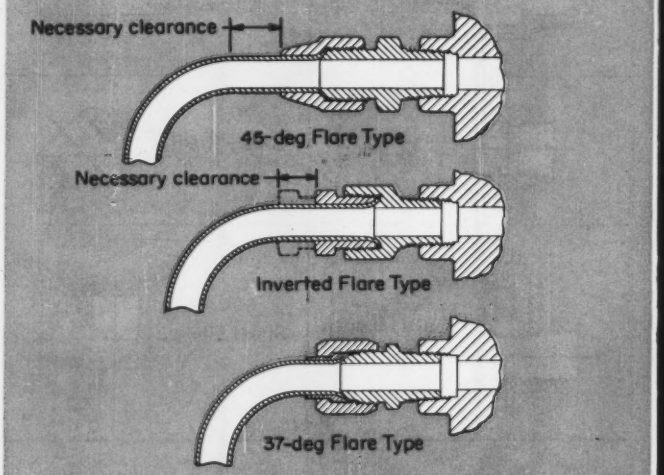

Fig. 6—Comparison of straight lengths required from tube end to start of bend for various flare fittings.

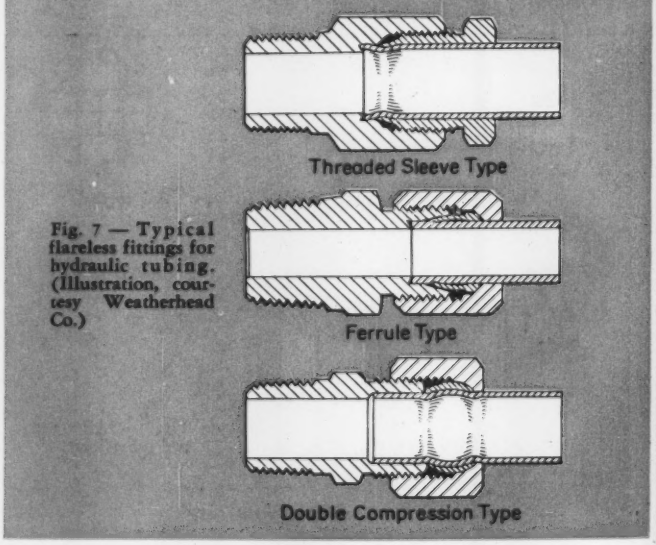

Fig. 7 — Typical flareless fittings for hydraulic tubing. (Illustration, courtesy Weatherhead Co.)

Table 3—Pipe, Tubing and Hose Size Comparison and Fitting Thread Systems

Tube OD (in.)	Corresponding Pipe Size (in.)	Hose ID for SAE Types 1-4*	Hose ID for SAE Types 5†	SAE-JIC 37-deg Thread	SAE 45-deg Thread	SAE 45-deg Inverted Thread
1/8	1/8	..	..	5/16-24	5/16-24	5/16-24
3/16	1/8	1/4	1/4	3/8-20	3/8-20	3/8-24
1/4	1/4	1/4	1/4	1/2-20	1/2-20	1/2-20
5/16	1/4	..	5/16	5/8-18	5/8-18	5/8-18
3/8	3/8	..	..	....	11/16-16	11/16-18
1/2	3/8	3/8	11/32	3/4-16	3/4-16	3/4-18
5/8	1/2	1/2	1/2	7/8-14	7/8-14	7/8-18
3/4	3/4	3/4	5/8	1 1/16-12	1 1/16-14	1 1/16-16
7/8	3/4	3/4	..	1 3/16-12	1 1/4-12	
1	1	1	7/8	1 5/16-12		
1 1/4	1 1/4	1 1/4	1 1/4	1 5/8-12		
1 1/2	1 1/2	1 1/2	1 5/8	1 7/8-12		
1 3/4	1 3/4	..	..	2 1/4-12		
2	2	2	1 13/16	2 1/2-12		

*Type 1-4: SAE 100R1 to SAE 100R4 †Type 5: SAE 100R5

bility for weakening in the tube material of the flare bend is reduced. Torquing the nut presses a wedge-shaped sleeve against the tubing end and a mating female part of the fitting, creating a flare type enlargement on the tube ends. This fitting works best on thin-wall tubing where large torques are not required to produce the flaring action. The joint is mechanically strong, vibration resistant, and re-usability is unlimited.

Flareless Types: These fittings do not require a flaring operation, and are not limited in use by tube sizes and operating pressures, Fig. 7.

COMPRESSION FITTINGS: One type of this fitting consists of two pieces, a body and a nut which serves a double purpose, acting as a tube sleeve and tightening nut. As the nut is advanced, the end is squeezed against the tubing wall, forming a slight compressive deflection which produces sealing action. The fitting body incorporates an inverted type tube seat which tends to expand the end as the tube is pushed forward by the nut. This fitting is used on soft, thin-wall tubing for low-pressure applications, when ease of assembly and disassembly is a factor. The nut has a tendency to loosen when subjected to vibration, restricting the recommended use of the fitting.

The second type of compression fitting achieves a sealing effect when both ends of a sleeve, compressed between the fitting body and the advancing nut, deflect into the outer surface of the tubing wall, forming two parallel grooves.

Condition for this action can be achieved only in thin-walled tubing of soft material. Since sealing action is performed through the surface-type non-destructive contact between sleeve and tubing, smoothness of the tubing surface is important. Use of this type fitting is limited to low-pressure applications on vibration-free systems.

FERRULE FITTINGS: The sealing effect in this fitting is accomplished by forcing the edge of a ferrule or sleeve into the tubing wall, creating a destructive shear and subsequent interference seal, Fig. 7. The result is a strong mechanical joint, developed through the spring action of the sleeve, which is leakproof up to very high pressures. In addition, the fitting resists vibration. However, a certain minimum wall thickness is required because of the high stress concentration on the bite mark. Wall thickness on the high side is unlimited. Limited reassembly is permissible and will produce a leakproof joint each time.

O-RING FITTINGS: The main advantage of this type of fitting is the separation of the O-ring sealing element from the tube-retention element, the tapered grip spring. Very low tightening torque is required, tube ends need not be square, no stress concentration is set up in the tube wall, and number of reassemblies is unlimited.

Correct assembly must leave sufficient length of tubing inside the fitting to assure adequate support for the O-ring. The estimation of this length is somewhat difficult as it cannot be observed or controlled from the outside. Proper performance also depends on a close dimensional match between the fitting and tube which, however, should present no particular problem with quality hydraulic tubing.

Hose Fittings

To connect hose to other circuit components, the hose end must be provided with a coupling which, in turn, is attached to the proper fitting, Fig. 8. One side of the fitting must be of a design that will correspond to the type of coupling used. To describe hydraulic hose connections, the hose coupling and the actual fitting must be included.

Most hose end couplings can be obtained in permanently pressed-on designs, re-usable clamp designs, and re-usable screw-type designs. The re-usable type couplings require appreciable skill and time for their assembly. This circumstance limits their preferable usage to experimental installations, and to permanent applications where it is possible to make field repairs. For mass-production applications, the pressed-on type couplings have economic advantage.

For hose installation, a preferable practice is for both ends of the hose to be connected by union connectors which incorporate a free-turning nut.

Nuts are located either in the hose-end coupling or in the connector fitting. For short hoses, it is possible to have one end rigidly connected. In this case, the whole hose has to turn during assembly. Unions are more expensive than rigid fittings. Hence, it is often preferable to locate the union in the connector fitting rather than in the hose coupling.

A considerable number of hose-end coupling designs are available, differing in the basic principle employed and in the type of flare and thread used.

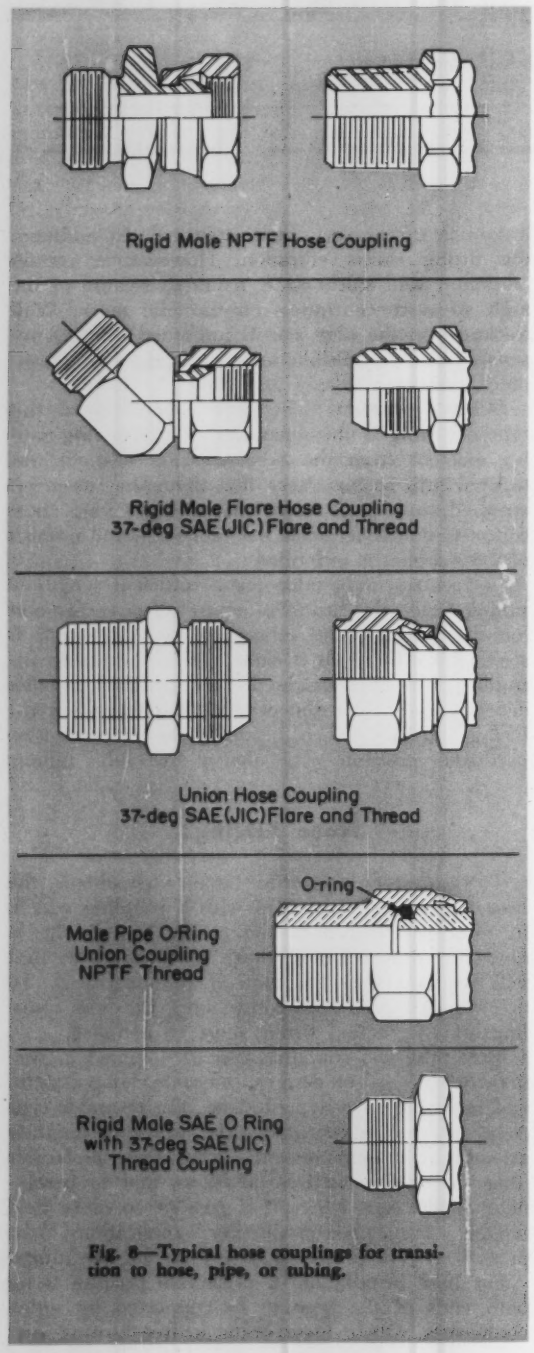

Fig. 8—Typical hose couplings for transition to hose, pipe, or tubing.

Rigid Male NPTF Pipe Thread Coupling: One of the most commonly used, this coupling has a 30-deg internal flare angle, Fig. 8, and must be used with a female union connector or adapter which also has a 30-deg male flare and NPSM thread. A complete selection of these union fittings is available; this hose assembly can be connected to male or female pipe threads, SAE O-ring ports, or any type of flared or flareless tubing.

Rigid Male Flare Coupling: This coupling seals by means of a male flare corresponding to the types used for tubing. Preferred for use on hose is the 37-deg SAE thread type, Fig. 8. The union fitting of this connector must also have a matching thread and female flare.

Union Hose Coupling: This fitting contains a free-turning nut with a female flare of 37 deg and corresponding SAE thread. Thus, this connector is a rigid type fitting with a 37-deg flare.

Male Pipe O-Ring Union Coupling: This design incorporates an O-ring seal into a male NPTF threaded free-turning part. Since the O-ring seals properly only under pressure, use of this connector is limited to applications where an occasional leak is not objectionable.

Rigid Male SAE O-Ring Coupling: The SAE O-ring thread end on this connector permits it to be assembled directly, without connector fittings, into SAE O-ring ports. During assembly, the hose must be free to turn.

Flange Coupling: The split-flange type of design is the most frequently used. The hose connection can be of the clamped, re-usable screwed or permanently attached type. If flange connections between two lines are desired, the port flange is used on both lines, but a sandwich plate is inserted between them to form the sealing surface. Unlimited re-usability is the outstanding advantage of these connectors.

Previous articles in this planned program on hydraulic lines have appeared in the April 16, 30, May 14, 28, and June 11 issues of MACHINE DESIGN.

Copies of the entire series, "An Engineering Approach to Hydraulic Lines," bound as a pamphlet, may be obtained for $1.00 each from: Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

The most suitable thermoplastic for an application isn't necessarily the newest one. Often, all it takes to solve a design problem is a review of the advantages offered by a proved material.

Here, such a review covers properties, applications, and design tips for

Updating the Butyrates

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Eastman Chemical Products Inc.
Kingsport, Tenn.

CELLULOSE acetate butyrate offers a combination of properties not found in any other transparent thermopastic material. It has exceptional toughness, high impact resistance, and excellent dimensional stability. The hardest flows resist distortion under heat at temperatures to 227 F. Also, it is available in an unlimited range of colors, is not brittle or readily flammable, and can be fabricated quickly and economically. Part finishing is rarely required because of the plastic's high surface luster.

Butyrate is available in various grades of hardness or flows and in nine basic formulations adaptable to various process methods, Table 1. Each formulation is designed for different end-product requirements. Compared to other thermoplastics, butyrate has the economic advantage of a very rapid forming cycle and can be vacuum formed, injection mold-

Table 1—Butyrate Formulations and Characteristics

Formulation	Flow*	Properties
205	H and H2 for extrusion, MS for injection molding	High impact strength at room temperature and low temperature. Provides maximum serviceability over a wide temperature range.
218	MH to MS	Excellent permanence, good toughness, low water absorption, low moisture transfer.
233	MS	High flexural strength, tensile strength, and modulus of elasticity, low water absorption.
239	MH to MS	Excellent impact strength, good toughness at low temperature, retains adequate strength and hardness at high temperatures, serviceable over a wide temperature range.
265	MS to MH	Has the highest impact strength at room temperature and low temperature of any butyrate available. Provides maximum toughness over a wide temperature range.
268	H and H2 for extrusion, MS for injection molding	A good general-purpose material. Provides excellent strength and brilliant finish. In soft flows, other formulations have better permanence properties.
435	MH and H2 for extrusion, MS for injection molding	Similar to Formulation 205 but has somewhat greater toughness at low temperatures.
455	MS	Similar to Formulation 233 in mechanical strength and hardness, but has higher low-temperature impact strength. Recommended for applications requiring soft flow but good surface hardness and toughness, and excellent permanence properties.
460	MS to MH	Excellent resistance to outdoor weathering, otherwise similar to Formulations 205 and 435.

*Flow ranges from soft to hard in this order: S4, S3, S2, S, MS, M, MH, H, H2, H3, and H4. The letter and number form a designation which indicates flow temperature. M flow (medium) is defined as 293 ±9 F, the temperature at which the material under 1500 psi will flow through a ⅛-in. orifice at the rate of ½ in. per min. Temperatures vary from 293 F in increments of +9 F for harder flows (MH = 309 F) and in increments of −9 F for softer flows (MS = 204 F). Flows can also be formulated and added to either end of the scale provided that flow temperature varies in the appropriate direction by 9 F.

ed, extruded or blow molded. The complete range of properties of the butyrate formulations is shown in Table 2.

Selecting the Forming Process: Generally, tolerances of ±0.001 in. are attained by molding or extruding. Parts can be vacuum formed from extruded butyrate sheet if tolerances required are on the order of ±0.010 in.

Parts having relatively large areas, uniform wall thickness, and no negative draft or undercuts can be formed most economically from extruded sheet. Molds for thermoforming are less expensive than tooling required for injection molding.

For extrusions, cost of the material is the same as that for injection molding, but tooling costs are generally lower. As for thermoformed parts, extrusions may also require subsequent trimming and additional finishing.

Choice of a formulation of butyrate for injection molding depends on mold design and flow requirements. Maximum dimensional stability in the product is obtained with the hardest flow of butyrate which also fulfills other design requirements. Degree of flow in itself is not always indicative of the hardness of the molded article; but within the same formulation the harder flows generally give a harder surface, higher heat resistance, and greater rigidity and tensile strength. Softer flows impart greater impact strength.

Joining Methods: Butyrate parts can be fastened mechanically or with adhesives which require no heat or sustained pressure for curing. In bonding butyrate to other plastics mechanically, Table 3 should be used as a guide. It shows the softest flows of the various butyrate formulations which may be safely used in direct contact with other plastics. Note that in the case of a cement bond, the butyrate is in contact with the cement—not with the other material to which it is bonded.

Mechanical methods of assembly are usually preferred for joining butyrate to acetate, vinyl, styrene or modified styrene, or nonplastic materials. Ce-

Table 2—Range of Butyrate Properties

Specific gravity at 68 F	1.15 to 1.22
Density (oz per cu in.)	0.67 to 0.71
Specific volume (cu in. per lb)	22.5 to 23.9
Elongation (per cent)	40 to 88
Izod impact strength (ft lb per in. of notch)	
−40 F	0.4 to 1.7
73.4 F	0.8 to 6.3
Tensile strength at fracture (psi	
73.4 F	2600 to 6900
158 F	1000 to 5700
Flexural strength at yield (psi)	1800 to 9250
Compressive strength at yield (psi)	2100 to 9400
Modulus of elasticity, flexure (psi)	0.55 to 1.85 x 10^5
Water absorption, 24 hr (per cent)	0.9 to 2.2
Hardness, Rockwell R	31 to 116
Temperature of distortion under heat (F)	
264-psi load	113 to 202
66-psi load	130 to 227
Deformation under load or cold flow (per cent)	1 to 52
Thermal conductivity (cal/sq cm/sec/deg C/cm)	4 to 8 x 10^{-4}
Thermal expansion (in./in./deg F)	6.1 to 9.4 x 10^{-5}
Flow temperature (F)	257 to 347
Mold shrinkage (in./in.)	0.002 to 0.003
Shrinkage subsequent to molding; 40 per cent relative humidity and 75 F for 1 yr (in./in.)	0.003 to 0.005
Dielectric strength, 1/8-in. specimen, 60 cycles, 50 per cent relative humidity (v/mil)	250 to 400

Tips for Designing in Butyrate

Injection-Molded Parts

1. Design reinforcing ribs into large, flat areas. Ribs not only strengthen the part but aid in filling the mold cavity quickly and uniformly.
2. Specify maximum rib thickness to 75 per cent of the thickness of the wall reinforced to prevent surface sink marks. Rib height should equal at least 1½ times the wall thickness.
3. Check rib design as possible cause of air pockets or undesirable flow conditions in the mold.
4. Specify mold parting lines on hidden surfaces of the part when possible.
5. Avoid abrupt changes in thickness in cross sections and specify a minimum radius of 1/16 in. on corners and fillets. Wall thickness should not vary through corners.
6. Provide maximum draft angles permitted by considerations of part function and appearance.
7. Provide for removable cores where pronounced undercuts are required and for auxiliary core-pulling devices for oblique holes and holes parallel to the mold parting line.
8. Specify sand blasting or vapor blasting for core surfaces to prevent sink marks on surfaces above cored holes. Sink marks result from the vacuum formed when the core is withdrawn.
9. Specify external threads at right angles to mold parting lines. Internal threads require either a separate mold part or a threaded core actuated by a power-driven unscrewing device.
10. Provide for molded-in threaded inserts where necessary rather than drill and tap the part. Inserts tend to reduce cold flow in an assembly under strain.
11. Specify press-fit fasteners for molded holes where practical. Heating the insert to approximately 300 F before insertion lessens the chance of inducing strain in the molded piece.
12. Specify diameters of molded holes at least 2 per cent smaller than the insert OD and possibly smaller if insert shanks have deep knurls.
13. Specify oxidizing by baking for brass inserts to make them less conspicuous when molded in transparent material.
14. Consider subsequent part shrinkage in design (distinct from mold shrinkage). Parts shrink about 0.005 in. per in. at room temperature. Approximately 75 per cent of total shrinkage takes place within 48 hr after removing

Table 3—Recommended Softest Butyrate Flow for Direct-Contact Use with Other Plastics*

Plastic	Flow for butyrate formula No. . . .								
	265	239	205	435	460	218	268	233	453
Polystyrene and high-percentage styrene copolymers	MH	H2	MH	MH	MH	MH	MH	MS	MS
Methyl Methacrylate	S4	S2	S4	S4	S4	S4	S4	S4	S4
Polyethylene	S4	S4	S4	S4	S4	S4	S4	S4	S4
Vinyl chloride acetate	MS	MS	S2	S2	S2	MS	S2	S2	S2

*Any flow no softer than those listed is satisfactory for direct-contact use with materials shown.

mented bonds between two pieces of butyrate or between butyrate and some other plastic may be made as strong as the plastic itself. Suitable adhesives for bonding butyrate to other materials are shown in Table 4.

Internal threads, if coarse and shallow, may often be molded in butyrate and the finished piece forced from the core without damage. Finer or deeper threads may be formed by drilling and tapping the plastic, but it is usually more desirable to mold a threaded metal insert into the piece.

Self-tapping or thread-forming screws are preferred because of the thread-to-thread contact which provides greater strength. A variation of these is the drive screw, intended only for permanent assemblies. Butyrate can be easily swaged by means of pressure and a heated tool. In some cases, this permits assembly of parts without screws or other fasteners. If machine screws or bolts are used, matching holes must be drilled in both pieces.

Butyrate sheet can be drilled without the risk of subsequent crazing, and self-threading screws will not break or crack the surface as they are installed. Other satisfactory mechanical methods of joining butyrate parts include riveting and stapling.

Finishing: Vacuum-formed extruded sheet is often finished simply by trimming the edges with ordinary shop tools or cutting dies. Injection-molded parts can be turned or threaded on a lathe, milled, sawed, sanded, lapped, or wheel-polished and buffed.

Table 4—Adhesives for Joining Butyrate and Other Materials

Material	Adhesive*
Cellulose acetate	A
Cellulose acetate butyrate	I
Cellulose acetate propionate	I
Cellulose nitrate	A
Ethyl cellulose	A
Polystyrene	F
Polyvinyl chloride	F
Metal	A, B, C
Glass	A, C
Masonry	G, H
Porcelain, ceramics	E
Wood	A, C
Rubber	C
Cloth, felt	A, C, D, I
Leather	A, C, I
Paper	A, C, D, I

*Adhesive	Name	Description	Supplier
A	Pyroxcote 36-208-1	Clear, nitrocellulose base	Pyroxylin Products Inc., Chicago
B	Metallic X Liquid Mender	Aluminum colored, nitrocellulose base	Lux-Visel Inc., Elkhart, Ind.
C	EC-776	Transparent amber, synthetic-rubber base	Minnesota Mining & Mfg. Co.
D	EC-2002	White synthetic-resin emulsion, colorless, nonflammable	Minnesota Mining & Mfg. Co.
E	EC-969	Tan paste	Minnesota Mining & Mfg. Co.
F	Cordo Bond C-89D	Clear, vinyl base	Cordo Chemical Corp., Norwalk, Conn.
G	Tempotite 2L Tempotite 6	Black mastic Black viscous liquid	Tempotite Plastic Co., New York
H	Miracle Adhesive Type M	Black reclaimed rubber-resin base	Miracle Adhesive Corp., New York
I	Cement No. 5576 for Tenite Butyrate	Clear, cellulose acetate butyrate base	Eastman Chemical Products, Inc.

the part from the mold. Mold shrinkage usually averages from 0.002 to 0.003 in. per in. but varies with molding considerations.

Thermoformed Parts

1. Apply the same general considerations as for injection-molded parts.
2. Design large, flat areas slightly convex if ribs cannot be concealed or made part of the design.
3. Consider certain advantages of drawing sheet over a male mold rather than into a female mold. The heated sheet has less tendency to stretch at points of deepest draw thus minimizing thin spots. Also, the appearance surface is not in contact with the mold and presents a lustrous finish.
4. Specify a female mold when accurate reproduction of details on the appearance side of the part is required.
5. Consider the type of mold material in relation to the number of finished parts required. Suitable materials include pressed and laminated wood, high-strength gypsum cements, poured thermosetting resins, and metal. The least expensive materials, however, are likely to develop defects early in use.
6. Specify draft angles of at least 5 deg on all protruding portions and sides of the mold to facilitate part removal.

A Novel

Linkage Design Technique

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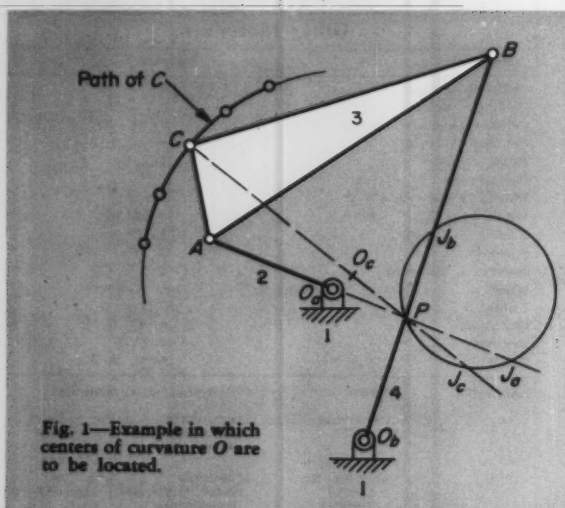

Fig. 1—Example in which centers of curvature *O* are to be located.

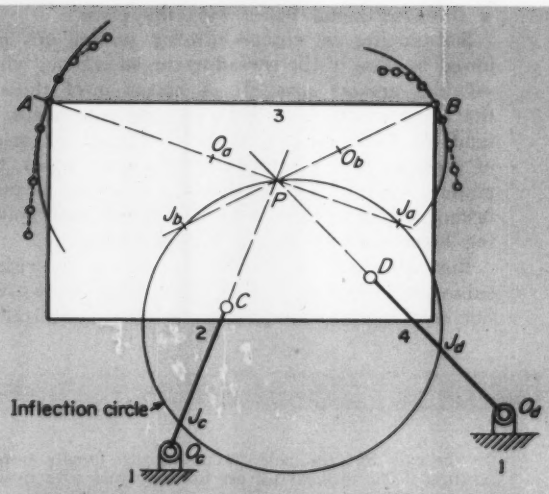

Fig. 2—Example in which *C* and *D* are to be located to provide motions of *A* and *B* in link 3.

OF basic importance in the kinematics of machines, the concept of the inflection circle, and the relation known as the Euler-Savary equation, are the foundations of this article. Disregarded by most textbook writers, they are unknown to many design engineers who could put them to practical use. This article presents working tools, based on these ideas, reinforced by simple application examples.

Inflection Circle

Consider two rigid bodies in plane relative motion. Body 1 is fixed. As body 2 moves, different particles or points trace paths of different shapes. At any position of body 2, some of these paths have large curvature, some have small curvature, and some have zero curvature (infinite radius of curvature). It can be shown that all particles on paths of zero curvature, in a particular body position, lie on a circle. This is called an "inflection" circle because all particles located on it are, at the instant, passing through inflection points in their paths.

It can be shown further that the instant center of rotation common to the two bodies is always on

Useful concepts in design of mechanisms are the inflection circle and polode curvature. They comprise a simple technique for mechanism analysis and synthesis, both graphical and analytical. In particular, they aid in substituting four-bar linkages for other motion generators.

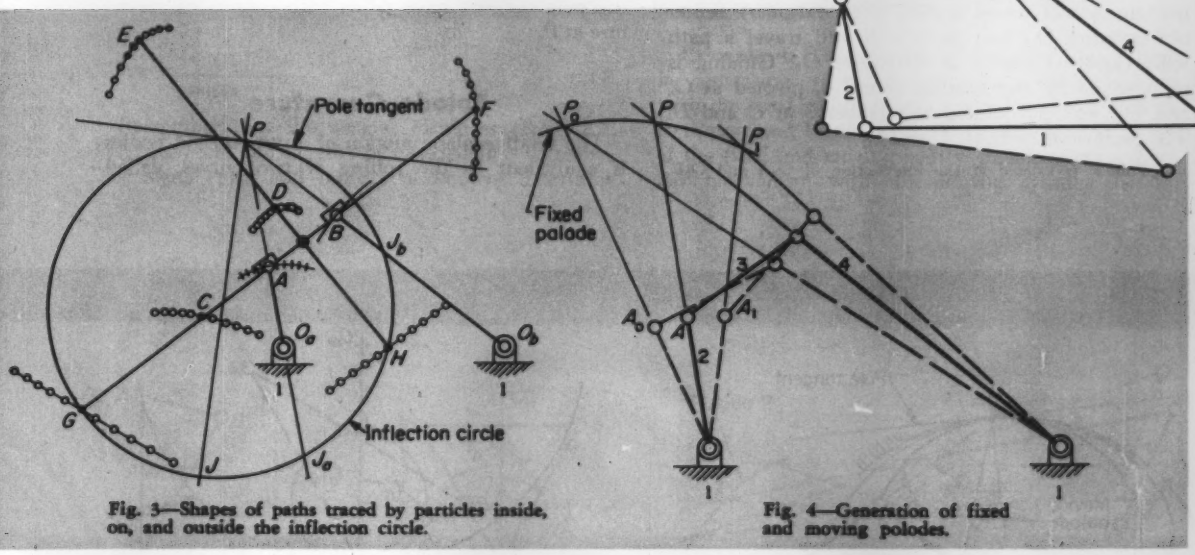

Fig. 3—Shapes of paths traced by particles inside, on, and outside the inflection circle.

Fig. 4—Generation of fixed and moving polodes.

Nomenclature

- J = On an inflection circle, the intersection with a line passing through P and a point in a body in relative motion.
- n = Velocity ratio of two crank members, ω_4/ω_2.
- O = Instant center of curvature of the path of a particle in a body in relative motion.
- P = Pole point, the instant center of rotation common to two bodies in relative motion.
- γ = Included angle between pole normal and lines, through the pole, to significant linkage points, $A, B, \ldots$

the inflection circle. This point of zero relative velocity is called the "pole" P. Since three points define a circle, P and two other points define an inflection circle. The other two points are found with the aid of the Euler-Savary equation. This equation relates, mathematically, four significant places or points in the system. Representative points are shown in Fig. 1 on lines J_aA, O_bB, or J_cC. The points are: Pole P; particle A (or B, etc.) belonging to the moving body; center of curvature O_a (or O_b, etc.) of the path of that particle; and intersection point J_a (or J_b, etc.) where the line containing these three points crosses the inflection circle. Two forms

of the Euler-Savary equation for particle A (or B, etc.) are

$$O_aA = \frac{(PA)^2}{J_aA}, \quad O_bB = \frac{(PB)^2}{J_bB}, \ldots \qquad (1)$$

$$\frac{1}{PA} - \frac{1}{PO_a} = \frac{1}{PJ_a}, \quad \frac{1}{PB} - \frac{1}{PO_b} = \frac{1}{PJ_b}, \ldots \qquad (2)$$

Symbol sequence indicates *directed* distances. Hence $O_aA = -AO_a$, and $PA = -AP$. As Equation 1 indicates, O_a and J_a always fall on the same side of A.

Applications of the inflection circle and the Euler-Savary equation are illustrated in Examples 1 and 2.

Example 1: Find the radius of curvature of the path of particle C in Fig. 1. The procedure is:

1. Find P for motion of link 3 relative to fixed link 1.
2. Solve Equation 1 for J_aA to locate J_a.
3. Repeat for point B to locate J_b.
4. Draw the inflection circle through points P, J_a, and J_b.
5. Connect C with P and mark J_c where CP crosses the inflection circle.
6. Apply Equation 1 to find O_cC, the required center of curvature.

Example 2: In Fig. 2, design a guide for member 3 so that, in the vicinity of the position shown, particle A will travel a path with (known) center of curvature O_a, and particle B will travel a path with (known) center of curvature O_b. Guiding is to be done by two cranks, 2 and 4, pivoted at O_c and O_d, and pin-jointed to member 3 at C and D. The problem is to locate C and D.

1. Pole P is located at the intersection of O_aA and O_bB.
2. Use Equation 1 to locate points J_a and J_b where PA and PB cross the inflection circle.
3. Draw the inflection circle through P, J_a, and J_b. Mark points J_c and J_a where PO_c and PO_d cross the inflection circle.
4. Solve Equation 2 for PC and PD to locate points C and D. The procedure is to substitute known distances PO_c, PJ_c, PO_d, and PJ_d into these equations and solve for unknowns PC and PD. Fig. 3 shows that actual paths of A and B do closely approximate the circular arcs required.

Shapes of Traced Paths: Further understanding of the inflection circle concept may be gained from Fig. 3, which represents a four-bar mechanism with extensions of the coupler AB. Paths traced by a number of particles attached to the coupler are plotted for short distances. The inflection circle relates motion of the coupler to the fixed link. The line tangent to the inflection circle at P is called the "pole tangent." Observations are:

1. Particles of the moving body, outside the inflection circle, have paths concave toward P.
2. Particles inside the inflection circle have paths concave away from P.
3. Particles on the inflection circle have paths which approximate straight lines for some distance.

Although not demonstrated here, all particles on the pole tangent have paths with centers of curvature at P.

Polode Curvature

The relative plane motion of any two rigid bodies is equivalent to the rolling of two curves, called

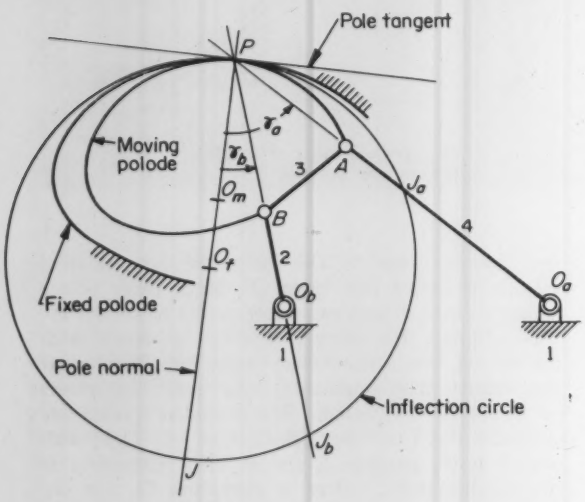

Fig. 5—Geometry of fixed and moving polodes.

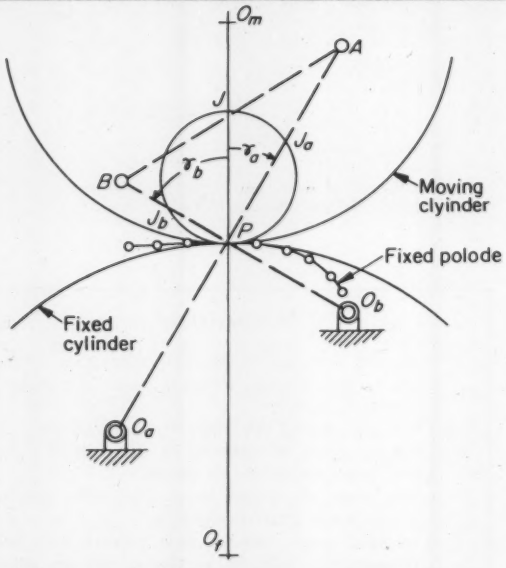

Fig. 6—Design of a four-bar mechanism to guide a moving cylinder in rolling contact with a fixed cylinder.

"centrodes" or "polodes." This article uses the latter term. Polodes are obtained by plotting the paths of poles P. The "fixed" polode is the locus of the pole with respect to the fixed link 1, Fig. 4. The "moving" polode is plotted by inverting the mechanism, holding link 3 fixed, and tracing the path of the pole. Fig. 5 shows both polodes.

An important observation is that the rolling of the moving polode on the fixed polode gives to all particles of link 3 exactly the same paths of motion as does the guiding of link 3 by cranks 2 and 4 of the four-bar mechanism.

Fig. 5 also shows the inflection circle for motion of link 3 relative to link 1, the pole tangent common to the polodes and the inflection circle, and the "pole normal." Points O_f and O_m are centers of curvature of the fixed and moving polodes at point P.

Radius of curvature of the fixed polode in Fig. 6 is

$$O_fP = \frac{2(PJ)}{r + s} \tag{3}$$

where

$$r = \left[3\left(\frac{PA}{O_aA} \right) - 1 \right](1 - K)$$

$$s = \left[3\left(\frac{PB}{O_bB} \right) - 1 \right](1 + K)$$

$$K = \frac{\sin(\gamma_b + \gamma_a)}{\sin(\gamma_b - \gamma_a)} \tag{4}$$

Remember that the various distances (PA, O_aA, PJ, . . .) are the lengths of *directed* line segments. The signs (plus and minus) of knowns determine the signs of unknowns. Angle γ_a is measured from positive line PJ to positive line PA. Angles γ_a and γ_b may be measured clockwise or counterclockwise, but both must be measured the same.

Examples illustrate application of the polode curvature equation in analysis (Example 3) and in design (Example 4).

Example 3: To demonstrate the use of the polode curvature equation, calculate O_fP in Fig. 5. Given: $PA = 2.75$ in. (taken positive), $O_aA = -5.05$ in. (negative because opposite to PA), $PB = 3.01$ in., $O_bB = -1.96$ in., $PJ = 8.01$ in. (always taken positive), $\gamma_a = 58.7$ deg, $\gamma_b = 18.6$ deg. Then K from Equation 4 $= -1.515$ and O_fP from Equation 3 $= -4.30$ in.

The negative sign means O_fP is opposite in sense to PJ. Hence, O_f is located as shown in Fig. 5.

After the center of curvature of either polode has been located, the other can be found from Equation 2, expressed

$$\frac{1}{PJ} = \frac{1}{PO_m} - \frac{1}{PO_f} \tag{5}$$

For this example, $PO_m = 2.79$ in. The positive value means PO_m is in the same sense as PJ, hence O_m is located as shown in Fig. 5.

Example 4: The moving cylinder in Fig. 6 is to be constrained to make approximate rolling contact with the fixed cylinder for a limited range of motion. It is proposed to pin-joint two links between points of the fixed and moving bodies, thus forming a four-bar mechanism with the moving cylinder as the

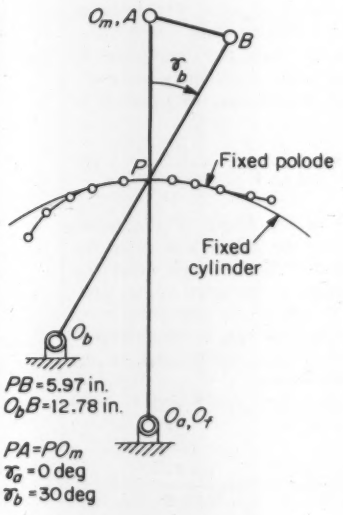

Fig. 7—Second estimate for example in Fig. 6.

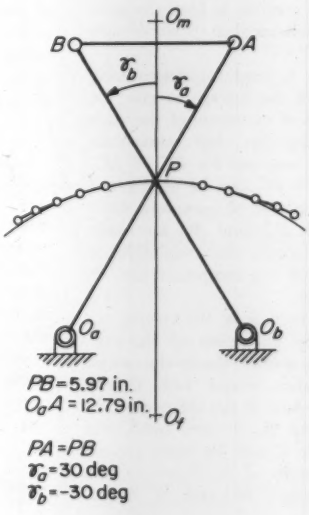

Fig. 8 — Third estimate for example in Fig. 6.

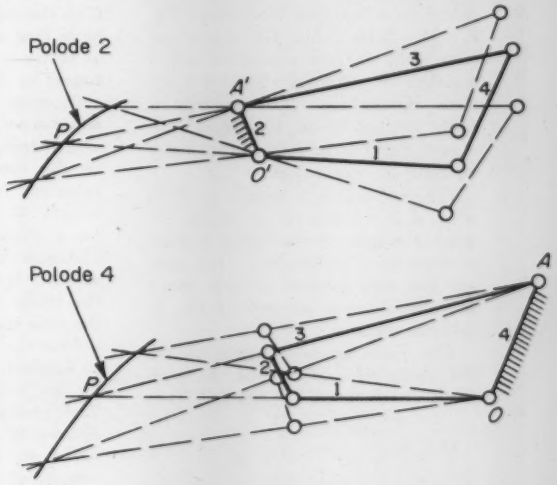

Fig. 9—Generation of crank polodes.

coupler. In the design position, centers of curvature of the polodes must coincide with the centers of the fixed and moving cylinders.

1. Determine the inflection circle diameter PJ from Equation 4. Here $PO_m = 6$ in. and $PO_f = 9$ in., hence $PJ = 3.6$ in.

2. Equations which must be satisfied are Equation 3 and two Euler-Savary equations.

$$O_aA = \frac{(PA)^2}{PA - PJ\cos\gamma_a} \qquad (6)$$

$$O_bB = \frac{(PB)^2}{PB - PJ\cos\gamma_b} \qquad (7)$$

These three equations have six unknowns: PA, PB, O_aA, O_bB, γ_a, and γ_b.

3. For a first solution, estimate $\gamma_a = 30$ deg, $\gamma_b = -60$ deg, and $PA = 2PJ_a$. Then,

$$PA = 2(3.60)\cos 30 = 6.23 \text{ in.}$$

$$K = \frac{\sin(-30)}{\sin(-90)} = 0.50$$

$$O_aA = 2PA$$

When all known quantities have been substituted in Equation 2, $PB = (0.456)(O_bB)$.

This expression, solved simultaneously with Equation 7, yields $PB = 3.31$ in., and $O_bB = 7.26$ in.

The resulting four-bar mechanism is shown in broken lines, Fig. 6. Part of the fixed polode is plotted for comparison with the fixed cylindrical surface. The agreement is not good because the fixed polode coincides with the fixed cylinder

Using the Inflection-Circle Concept in

A TOOL-GUIDE LINKAGE DESIGN

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CONCAVE profiles, very close to circular, can be cut by lathe tools guided by a four-link mechanism, Fig. E. The lathe frame, the saddle and cross slide, and the compound rest 3 are three of the links. Crank 2 completes the linkage. The assembly is easily adjusted to cut a range of radii —particularly large radii, where other methods are impractical.

The mechanism is simple to build when A is a link pivot, as shown, instead of a point constrained by a slider to move on a straight line. The linkage can turn profiles of any radius provided distances BC and AB can be properly adjusted.

The Euler-Savary equation relates the radius of curvature of the path of C, and distances PC and J_cC. Thus

$$O_cC = \frac{(PC)^2}{J_cC} \qquad (1)$$

where P to C is taken as the positive direction.

The length of link 2 does not affect the radius of curvature of the path of C in the design position, but it should be as long as possible to keep the path as nearly symmetrical as possible with respect to AC.

Equation 1 is used for determining adjustments of the linkage to give the desired radius of curvature of the path of the cutting tip. Any convenient value can be assumed for $BC = J_cC$. Length $AC = PC$ can be determined for a given radius of curvature O_cC. Distances AB, BC, and AC are easily adjusted by moving the cross slide on the saddle and the compound rest on the cross slide.

Note that motion of the cutting tip is supplied by movement of the saddle as it is driven along the ways. The mechanism would lock if AC equaled BC. Also if the difference between AC and BC is very small, the velocity of tip C will be much greater than the velocity of B. Therefore, the difference between BC and AC should be large enough to permit a suitable cutting tip velocity.

When a point traces a circle, change of path radius is zero. The locus of points on a moving plane which traces paths with stationary curvature is called the cubic of stationary curvature. In polar co-ordinates, its equation is

$$\frac{1}{r} = \frac{1}{M\sin\theta} + \frac{1}{N\cos\theta} \qquad (2)$$

where r is the length of the radius vector from the pole to a point on the curve and θ is the angle from the pole tangent to the radius vector. Constants M and N for any position of the moving link can be determined if r and θ for two points lying on the cubic are known.

For point B, $r = PB$ and $\theta = 90$ deg. Therefore,

$$\frac{\cos\theta}{r} = \frac{\cos\theta}{M\sin\theta}$$

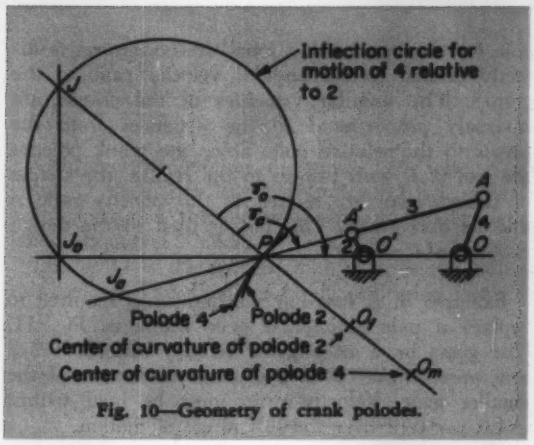

Inflection circle for motion of 4 relative to 2
Polode 4
Polode 2
Center of curvature of polode 2
Center of curvature of polode 4

Fig. 10—Geometry of crank polodes.

for an extremely short distance.

4. A better solution is shown in Fig. 7. Estimates were: $PA = PO_m$, $\gamma_a = 0$ deg, $\gamma_b = -30$ deg.

5. A still better solution is shown in Fig. 8. Estimates were: $PA = PB$, $\gamma_a = 30$ deg, and $\gamma_b = -30$ deg.

Crank Polodes

Crank polodes are equivalent rolling curves, turning around the crank pivots, which generate the same input-output motion relationship as does the four-bar mechanism. To plot the crank polodes for any four-bar mechanism, trace the locus of the relative pole (instant center) with respect to each of the cranks, Fig. 9.

The inflection circle for the relative crank motion of stationary curvature for link 3, in the design position, consists of a circle with diameter M along the pole normal and a straight line coincident with the pole normal. Since point C lies on the pole normal, the path of the cutting tip very nearly matches a circular arc in the vicinity of the design position.

and $\cos \theta = 0$

or $r = M \sin \theta$

These equations indicate that the cubic

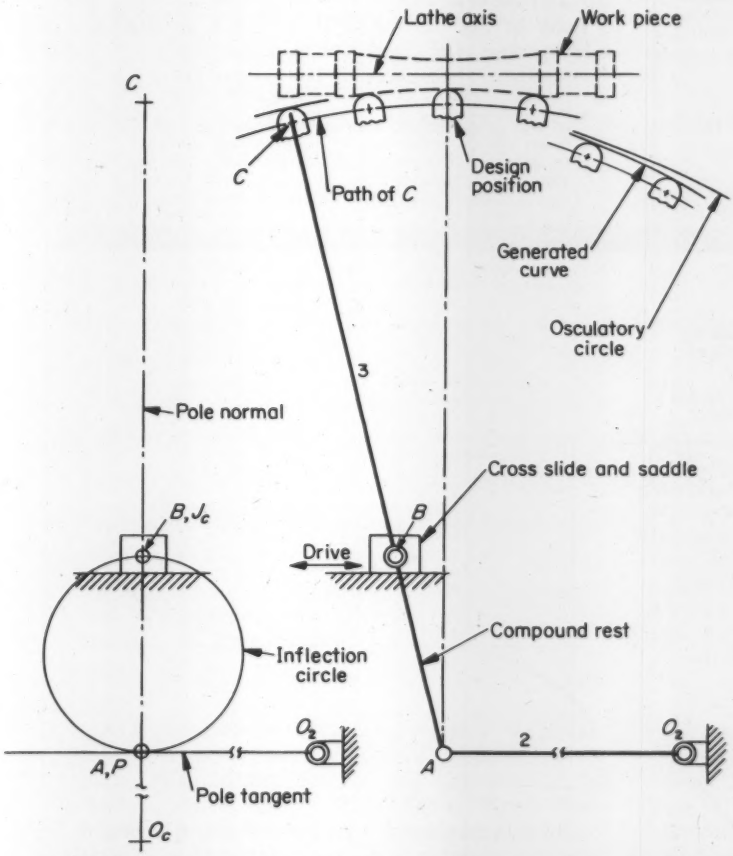


Fig. E—Four-link mechanism, adapted to a lathe, turns profiles which are approximate circular arcs. Sketch at left shows inflection circle for design position.

Practically, the tip of the cutting tool is not ground to a sharp point but a smooth curve. The point on the cutting tool at the center of curvature of the tip profile traces a path which has its center of curvature coincident with the center of curvature of the workpiece profile. Hence, O_cC in Equation 1 should be equal to $R - r$.

Example: A fatigue specimen must have a shape like the workpiece in Fig. E. The tool used to machine the specimen has a rounded tip with a radius of curvature of $\frac{1}{8}$ in. The workpiece profile radius is $9\frac{7}{8}$ in. Therefore, the value for O_cC is $9\frac{7}{8} - \frac{1}{8} = 9\frac{3}{4}$ in. For an assumed value of $4\frac{1}{2}$ in. for distance $BC = J_cC$, distance $AC = PC = 6.63$ in.

For $AC = 6.63$ in., $BC = 4.50$ in. and $O_2A = 20$ in., Fig. 1 shows the envelope of the cutting tool profile and its osculatory circle. Calculated maximum error is 0.0003 in. approx.

If O_2A is large, compared with the other linkage dimensions, the difference between the desired circle arc and the actual profile is

$$\Delta = \frac{b^2 - a^2}{b} - \frac{b}{a}\sqrt{a^2 - x^2} + \sqrt{\frac{a^4}{b^2} - x^2}$$

where Δ = Error measured perpendicular to the axis of rotation, $a = AC$, $b = BC$, and x = Axial displacement of the center of curvature of the cutting tool tip from the design position.

tion can be found by applying the Euler-Savary equation. For example, in Fig. 10, consider crank 2 fixed. As crank 4 is moved, points A and O travel circular arcs with centers at A' and O'. Hence,

$$\frac{1}{PJ_a} = \frac{1}{PA} - \frac{1}{PA'} \tag{8}$$

$$\frac{1}{PJ_o} = \frac{1}{PO} - \frac{1}{PO'} \tag{9}$$

With the points J_a and J_o located, the inflection circle can be drawn and its diameter PJ determined.

Equations 2 and 3, for radius of curvature of the fixed polode, apply here. In terms of the symbols used in Fig. 10 the equations are

$$O_fP = \frac{2(PJ)}{u + v}$$

$$\text{where } u = \left[3 \left(\frac{PA}{A'A} \right) - 1 \right] (1 - K)$$

$$\text{and } v = \left[3 \left(\frac{PO}{O'O} \right) - 1 \right] (1 + K) \tag{10}$$

$$K = \frac{\sin(\gamma_o + \gamma_a)}{\sin(\gamma_o - \gamma_a)} \tag{11}$$

The radius of curvature of the polode for crank 2 is O_fP. The center of curvature, O_m, of the polode for crank 4 is found from Equation 5.

Crank Speed Ratio: The location of the relative pole for the cranks of a four-bar mechanism is directly related to the angular velocity ratio of the cranks. The angular velocities of the cranks are inversely proportional to the distances from the pivots to the relative pole. Since the crank polodes are loci of P with respect to the cranks, the shapes of these curves are related to the velocity ratio n and its derivatives. This fact is used in the design problem of Example 5.

Example 5: A four-bar mechanism is required to replace a pair of circular gear segments, Fig. 11. The gears have an angular velocity ratio of $-3/2$ and operate over a 30-deg range of motion of the smaller gear. Velocity ratio must be held within ± 1.0 per cent over the full range of motion.

These specifications are quite narrow. To meet them, velocity ratio n, must be the desired value, and as many as practicable of the derivatives of n with respect to crank position must be zero. That is, in the immediate vicinity of the design position, the polodes of the relative motion must coincide closely with the gear pitch circles. The four-bar mechanism must be so proportioned that the polodes for the relative crank motion will have centers of curvature at O and O'.

Refer to Fig. 11. Let $O'O = l$. For an angular velocity ratio n of crank OA to crank $O'A'$,

$$n = \frac{\omega_4}{\omega_2} = \frac{O'P}{OP} \tag{12}$$

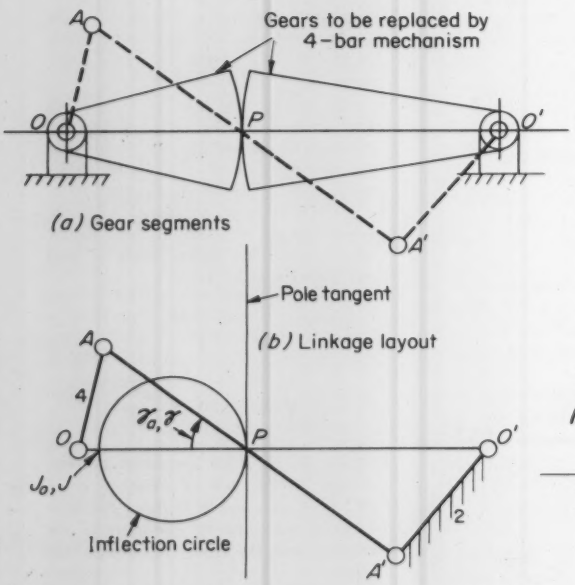


Fig. 11—Example in which a linkage replaces gear segments.

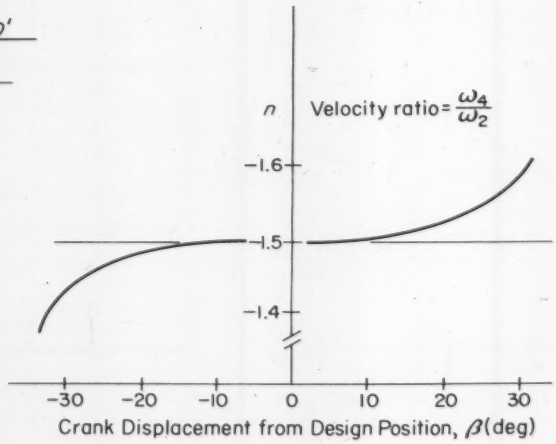


Fig. 12—Comparison of linkage performance with requirement to deliver constant velocity.

$$OP = \frac{l}{n-1} \tag{13}$$

$$O'P = \frac{nl}{n-1} \tag{14}$$

Consider the motion of crank OA relative to crank $O'A'$. In this inverted motion, O is a moving point and O' is the center of curvature of its path. Hence, Equation 9 holds.

Line $O'O$ is the pole normal, so J_o is the inflection pole J. The diameter of the inflection circle is

Summarizing Steps to Solutions

When a linkage must be designed for certain performance, the specifications can be formulated in a number of ways:

1. An equation for the displacement of the output crank versus position of the input crank.
2. Statements concerning the angular velocity ratio of the cranks and the manner in which this ratio is to vary with crank position.
3. Statements concerning the angular velocity, angular acceleration and rate of change of angular acceleration of the output crank for a specified constant angular velocity of the input crank.
4. Statements concerning torque ratio for the two cranks, and its manner of variation with crank position.

Any problem stated in one of these ways can be expressed in terms of the geometry of the crank polodes. In turn, crank geometry is related to linkage dimensions. If crank motion is not great in the range of specified conditions, a good design procedure is:

1. Determine the locations of the centers of curvature of the crank polodes to meet the design requirements at approximately the midposition of the motion range required.
2. Determine a set of link lengths which will yield polodes having these centers of curvature.
3. Determine whether the design requirements have been met throughout the desired range. If not, two recourses are available: a. If other designs exist for the problem as formulated, try them. b. Try making small modifications in the tentative design.

PJ. Expressions for PO and PO' from Equations 13 and 14, substituted in Equation 9 give

$$PJ = \frac{-nl}{(n-1)^2} \tag{15}$$

The equations for radius of curvature of the polode associated with fixed crank $O'A'$ is Equation 10, with O' substituted for O_f, and Equation 11. In these equations, γ_o is zero. Since γ_a is the only other angle, it is written γ. This information, plus Equation 15, reduces the radius of curvature equation to

$$3\left(\frac{PA}{A'A}\right) = \frac{n-2}{n-1} \tag{16}$$

Other expressions, similarly modified, are

$$PA = \frac{3nl\cos\gamma}{(1-2n)(n-1)} \tag{17}$$

$$A'A = \frac{9nl\cos\gamma}{(2-n)(2n-1)} \tag{18}$$

Equations 17 and 18 define the locations of A and A' for any value of γ. The restrictions placed on the design were not enough to determine γ, so a value can be chosen, say, 30 deg.

Fig. 12 shows the velocity ratio n as a function of displacement of crank OA from the design position. Calculated errors for $\beta = +13$ deg and -17 deg were found to be 0.4 per cent and 0.9 per cent. Curves for such problems should have large scales, and readings should be checked by calculation.

ACKNOWLEDGEMENT

This article, including the example by Wolford and Haack, is based on papers presented at the Fifth Conference on Mechanisms, cosponsored by Purdue University and Machine Design, October 13-14, 1958.

Conference Transactions

Transactions of the Fifth Conference on Mechanisms (239 pages), containing the 19 papers presented, are available at $3.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

They Say . . .

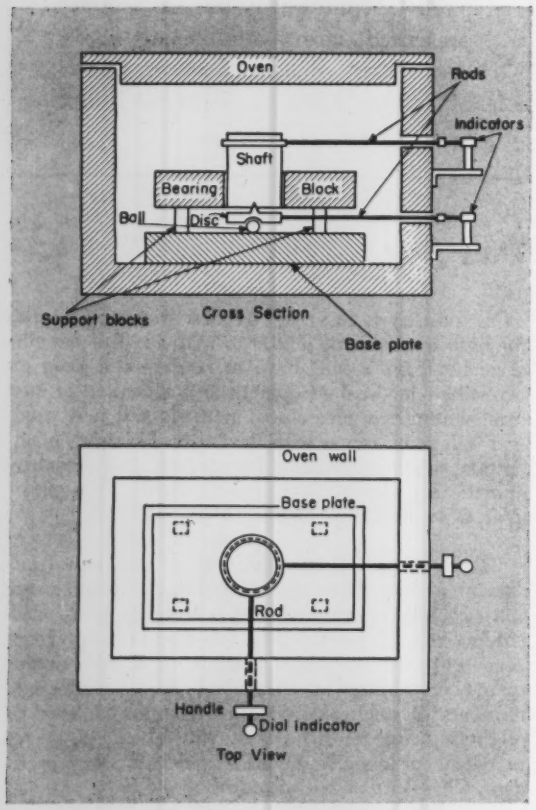
"If industry is to satisfy its own growing demands for high-level talent, if it is to reap the full benefits of technology, it will have to invest—and keep on investing—in the development and education of men from whom new ideas, new methods and new products will come—men with flexibility, foresight, imagination, a sound scientific foundation, and a healthy appetite for change."—JAMES C. ZEDER, *vice president, Chrysler Corp., Detroit, Mich.*

"Technology is boldly carrying us into new frontiers at a time when many of our old frontiers are still virtually unexplored. It's advancing at an electrifying rate of speed. And whether industry keeps pace with this advance depends to a vast degree upon our ability to train and develop adequate numbers of engineers who are capable themselves of staying abreast of—and staying ahead of—technological progress."—JAMES C. ZEDER, *vice president, Chrysler Corp., Detroit, Mich.*

Measuring Clearances at Elevated Temperatures

IN DESIGNING mechanical equipment to be operated at elevated temperatures, the problem is to know how the clearance between two closely fitted parts actually varies with temperature, or what the actual clearance between two parts is at any particular temperature. To complicate this problem, materials which are machined to odd configurations do not always expand uniformly when heated.

Clearances at various temperatures can be measured to an accuracy of ±10 per cent with the method presented here. Furthermore, the temperature has no effect on the measurement.



This technique consists of rigidly attaching rods to the inner part of two closely fitted components operating at high temperatures. These rods extend to the outside of the heating oven, and when moved from outside the oven, cause the inner part to move within the outer part. By measuring movement of the rods, the clearance between the inner and outer parts is determined. Since only the movement of the rods is measured, any change in rod length resulting from oven temperature change has no effect on the measurement.

A shaft and bearing assembly is used as an example in the figure. However, this technique can be used in many other applications.

The bearing block is supported above the base plate by support blocks. The shaft rests on a disc which, in turn, floats on a steel ball. The disc has a conical projection which engages the center hole in the shaft and forces the shaft and disc to move as one piece. Two rods are threaded into the disc at 90 deg to each other so that measurements can be taken in the two co-ordinates. Above the bearing block, two more rods are attached to the shaft through a collar arrangement. The rods are threaded through the collar and press against the shaft. Hence, the tightness of rods can be checked from outside the oven.

To take a measurement at any particular temperature, the dial indicators, or any other linear measuring devices, are adjusted to zero. This adjustment nullifies the effect of temperature on the actual rod length. As the top and bottom rods are moved in and out, the shaft moves from one side of the bearing to the other. Since the shaft reacts on a single ball bearing, only low forces are required to move it. Total movement of the rods, as measured by the dial indicators, is a measure of the total clearance. — W. L. Wood Jr., *Research Engineer, E. I. du Pont de Nemours and Co., Wilmington, Del.*

Minimizing Maximum Beam Deflection

Charts and equations for finding best location of supports

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DEFLECTION is often a controlling requirement in beam design. This article presents charts and equations for finding optimum location of supports to give a minimum value of maximum deflection in simply supported beam structures. A similar approach for minimizing maximum bending moments is detailed in a previous article (June 11, 1959, Page 173).

Two Supports—Uniform Load: For the symmetrical support arrangement shown in Fig. 1, maximum deflection in the overhang section of the beam is (see Nomenclature)

$$y_{max} = \frac{wL^4}{(2e+1)^4 EI}\left(\frac{t_0^4 + t_0 - e}{24} + \frac{e^4}{8} - \frac{e^3 t_0}{6} - \frac{e^2 t_0 - e^3}{4}\right) \quad (1)$$

where $e = c/d$ and y_{max} is the larger of the values computed at the tip, $t_0 = 0$, and at the intermediate point defined by $t_0 = [(4e^3 + 6e^2 - 1)/4]^{1/3}$.

Deflection at the center span is

$$y = \frac{w}{EI}\left[\frac{x^4 - 2x^3 d + xd^3}{24} + \frac{c^2(x^2 - xd)}{4}\right] \quad (2)$$

Maximum deflection in the center span can be determined from

$$4t^3 - 6t^2 + 12e^2 t - 6e^2 + 1 = 0 \quad (3)$$

$$y = \frac{wL^4}{EI(2e+1)^4}\left(\frac{t - 2t^3 + t^4}{24} + \frac{e^2 t^2 - e^2 t}{4}\right) \quad \ldots\ldots(4)$$

where $t = x/d$. Solution of Equation 3, which is the derivative of Equation 2 set equal to zero, gives the point on the beam at which maximum deflection occurs. Equation 4 is a simplified form of Equation 2 for maximum-moment calculations. Real, positive

Nomenclature

- c = Overhang or end span of beam, in.
- d = Intermediate span of beam, in.
- E = Young's modulus of elasticity, psi
- I = Moment of inertia of beam cross section about neutral axis, in.^{4}
- L = Beam length, in.
- w = Uniformly distributed load, lb per in.
- y = Deflection, in.

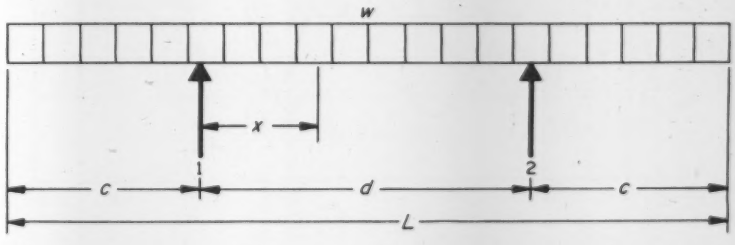

Fig. 1—Symmetrical two-support arrangement for beam with uniformly distributed load.

solutions of Equation 3 are substituted into Equation 4 to find the value of maximum deflection.

Effect of support location on deflection as determined by this approach is shown in Fig. 2. Intersection of the deflection plots defines the value of e at which maximum beam deflection is minimized: $e = c/d = 0.42$ or $c = 0.228L$.

When $e = 0$, the beam is simply supported at its ends. From Equation 4, then, maximum deflection is,

$$y_{max} = \frac{5wL^4}{384EI} \tag{5}$$

As e increases to a large value, maximum deflection is given by

$$y_{max} = \frac{wL^4}{128EI} \tag{6}$$

Three Supports—Uniform Load: For a beam with a symmetrical three-support arrangement, Fig. 3, deflection in each of the sections between supports is given by

$$y = \frac{wL^4}{16EI(e+1)^4}\left[\frac{t^4}{24} - \frac{t^3}{16} + \frac{t}{48} - \frac{e^2t^3}{8} + \frac{e^2t^2}{4} - \frac{e^2t}{8}\right] \tag{7}$$

where, again, $e = c/d$ and $t = x/d$.

Point at which maximum deflection occurs can be determined from

$$8t^3 - t^2(9 + 18e^2) + 24te^2 - 6e^2 + 1 = 0 \tag{8}$$

As e increases, y approaches zero. When $e = 0$, positive values of t from Equation 8 are $t = 1$ and 0.422. The latter value corresponds to maximum deflection y_{max} which is

$$y_{max} = \frac{0.0054wL^4}{16EI} \tag{9}$$

Maximum deflection in the overhang section of the beam is given by

$$y_{max} = \frac{wL^4}{16(1+e)^4}\left(\frac{t_0 - e}{48} + \frac{t_0^4}{24} + \frac{e^4 + e^3 - e^2t_0}{8} - \frac{e^3t_0}{6}\right) \tag{10}$$

where y_{max} is the larger of the values computed at the tip, $t_0 = 0$, and at the intermediate point defined by $t_0 = [(8e^3 + 6e^2 - 1)/8]^{1/3}$.

Maximum deflections for the three-support arrangement are plotted as a function of e in Fig. 4. Optimum condition is $e = c/d = 0.42$ or $c = 0.148L$.

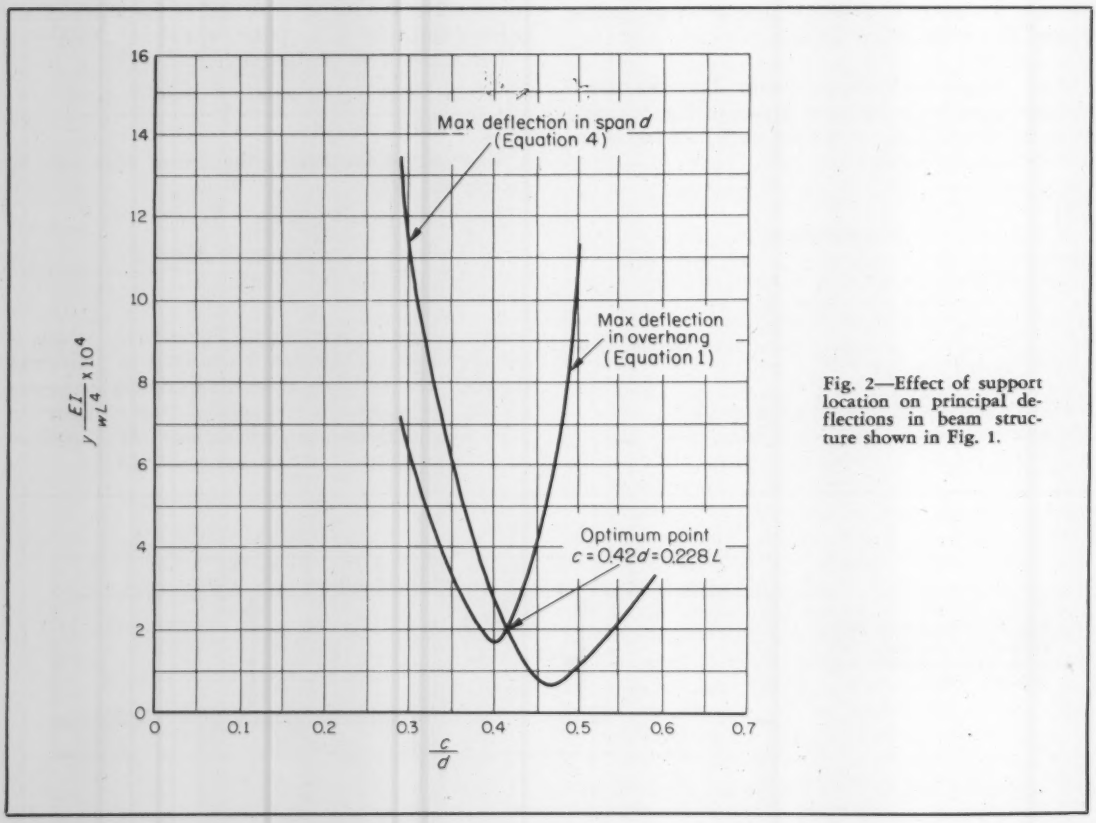

Fig. 2—Effect of support location on principal deflections in beam structure shown in Fig. 1.

Design Example: An aircraft control surface, which is 80 in. long, employs one beam member to resist bending loads. Find the optimum location for two hinges which act as simple supports if minimum deflection is the design criterion. Also, determine how much the deflection can be reduced if three support hinges are used instead of two with one of the hinges mounted at the midpoint of the beam span.

From Fig. 2, optimum condition for the two-support arrangement is $e = 0.42$. Span $d = L - 2c = L/(2e + 1) = 80/1.84 = 43.5$ in. Overhang $c = ed = 0.42(43.5) = 18.3$ in.

From Fig. 2 again, maximum deflection at $e = 0.42$ is

$$y = \frac{2wL^4}{10^4 EI}$$

From Fig. 4, optimum condition for the three-support arrangement is $e = 0.42$. Span $d = L/(2e + 2) = 80/2.84 = 28.2$ in. Overhang $c = ed = 0.42(28.2) = 11.8$ in.

Maximum deflection at $e = 0.42$ is, from Fig. 4,

$$y = \frac{5wL^4}{16(10)^4 EI}$$

Reduction in deflection obtained by using three supports rather than two is $100[2 - (5/16)]/2 = 84$ per cent.

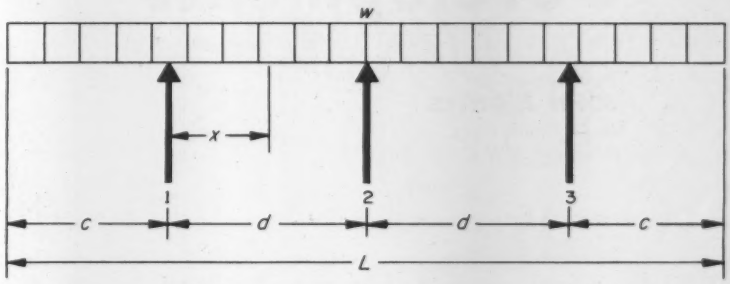

Fig. 3—Symmetrical three-support arrangement for beam with uniformly distributed load.

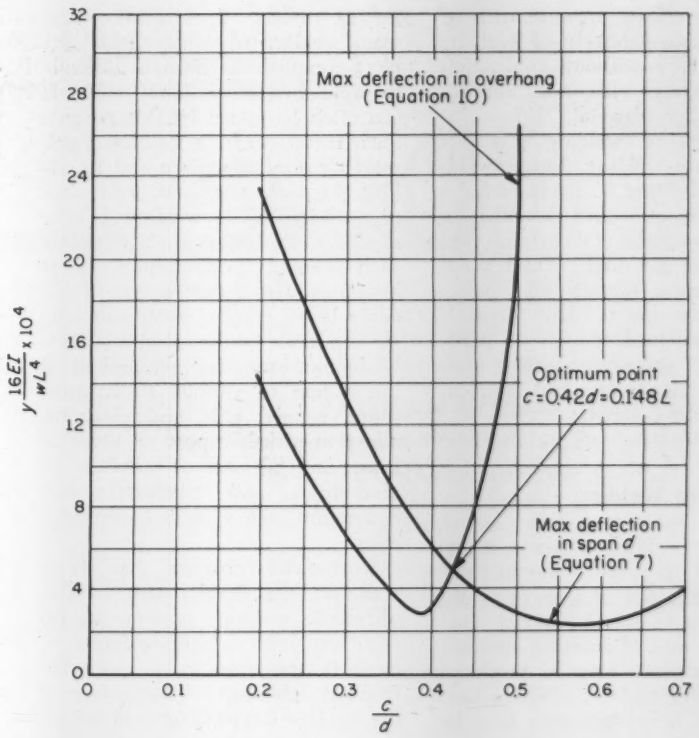

Fig. 4—Effect of support location on principal deflections in beam structure shown in Fig. 3.

New Welding Developments

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Milwaukee, Wis.

WELDING is defined as a process in which localized coalescence of metal is accomplished. Coalescence may be produced entirely by pressure with or without accompaniment of heat, by heating alone without application of pressure, and with or without additional filler material.

Three major welding processes are pressure welding, fusion welding, and brazing. Each includes several other processes classified according to source of heat and type of shielding gas used. Total available processes exceeds 65. Selection of any one of them depends on metals joined, design of parts, and cost of the process. The most recent developments and applications will be covered.

Pressure Welding

Pressure welding covers a group of related processes characterized by the application of force to obtain coalescence of metal, usually over the entire area of abutting surfaces. This coalescence may be produced with or without heat. Where heat is applied, these processes may be further subdivided as to the source and nature of the heat.

Ultrasonic Welding: In this process, energy to effect a weld is derived from special equipment using elastic vibratory energy for joining metals. Spot welding and seam welding of metal sheets can be accomplished. Metals difficult to weld by conventional methods can often be joined by this process. Such metals include stainless steel, molybdenum, zirconium and its alloys, Inconel, tantalum, and titanium. Ultrasonic welding is also used for joining dissimilar metals such as copper to aluminum. Combinations which can be joined include brass, copper, steel, and aluminum to zirconium; platinum, molybdenum, brass, Inconel, and silver manganese to various steels; titanium, copper, gold and platinum alloys to nickel; copper or silver to brass; molybdenum or tantalum to aluminum, and platinum and ruthenium alloys to a silver-gold alloy.

Substantial progress has been made in the development of the ultrasonic welding process in the past few years. Notable improvement in the strength of spotwelds has been obtained. This is largely the result of improvements in equipment and procedure. At the present time, the process is limited to joining light-gage or thin sheet materials. Foil thicknesses can be joined readily. Recent tests have been made with sheet-metal thicknesses of 0.090 in., and spot strengths substantially exceed Military Specification requirements. For example, tensile-shear strength of a spotweld in 0.025-in. Type 301 stainless steel is 1040 psi.

High-Frequency Resistance Welding: This is one of the newer processes which depends on high-frequency electrical energy to obtain the desired heating characteristics for welding. It depends on the fact that high-frequency current can be brought directly into the object to be heated by contact as well as induction. With the high-frequency method, alternating current generated from 100,000 cycles and upwards is connected directly to the work by contact electrodes. Current is arranged to flow in almost any desired path which often is not necessarily the low-resistance path.

The process is applicable to a wide variety of metals such as aluminum, brass, copper and copper alloys, stainless steels, silicon bronze, Monel, Inconel, and Incaloy. Some of the highly reactive metals such as titanium, titanium

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alloys, and zirconium alloys have been successfully welded with this process using inert gas for shielding. In addition, combinations of dissimilar metals have also been successfully welded, such as copper to aluminum.

One of the advantages of this process is the high speed that can be used. Speeds up to 1000 fpm can be obtained in light-gage materials 0.012 in. thick. The process is not limited to tubing, but can be applied to other shapes such as strips, T-sections, etc. Spiral strips of metal can be welded to the surface of tubes. Another advantage is the narrow heat-affected zone obtained due to the relatively narrow band of heating. This localized heating also accounts for the greater efficiency of the power used. The narrow weld zone results in high tensile strength and ductility.

Foil Seam Welding: This new process was developed in Europe and finds application where high-speed welding and freedom from distortion is important. This is a resistance welding process for making butt-type joints in flat strips or sheets, using a foil on top and bottom surfaces over the butt joint. The thin foil strips are from 5/32 to 3/16 in. wide and from 0.007 to 0.010 in. thick.

Joints are flat and require little if any final dressing of the weld metal. The surface of the weld can be painted or glass lined without subsequent grinding or processing operations. Basically, the same principles are employed for foil seam welding as for conventional seam welding except for modifications for foil addition. This process has future potentialities because of lower finishing costs and dimensional uniformity.

Magnetic-Force Welding: The basic principle of magnetic-force welding is the coupling of electrode force with magnetic force created by the welding current. Many difficult welding problems have been satisfactorily solved by this technique.

The magnetic-force welder is generally of a direct-acting piston or ram - type spotwelder redesigned to accommodate electromagnets for application of pressure. An air cylinder actuates the ram for positioning the weldments between the electrodes and also imposes a very slight or initial pressure on the work prior to welding. Some combinations of materials need a longer heating period before welding and a delay magnet is used. This gives a delayed forge-pressure application. As welding current begins to flow, magnetic force is delayed to actuate the forging blow. In most of the applications, welding time is of short duration.

The advantage of the magnetic-force welding process is that it can be used for welding high-conductivity metals to each other and to carbon steels. Improvement is obtained in the uniformity and consistency of welds produced. Many materials previously considered unweldable can now be successfully welded by magnetic-force.

Percussion Welding: This is a newly developed resistance-welding process in which the weld is made in an exceedingly short period of time over the entire area of the metals to be joined. Welds can be produced by either a rapid discharge of electrical energy from a stored-energy type of power source, or by rapid dissipation of current with a standard 60-cycle ac source. The principle of operation is that the part to be welded has a small pinpoint type of projection formed or coined into the part. This projection is instantaneously vaporized upon contact during the downward movement of the electrode. In the stored-energy type of equipment, an air cylinder controls the rapid movement of electrodes. In the resistance spotwelder, the magnetic force created by the welding current is used in the rapid movement of the electrode. Welding time is usually of ½-cycle duration.

One of the advantages of this process is that large-contact areas can be welded with small-capacity machines. Another advantage is that welding of dissimilar metals for high-conductivity electrical contact points is possible with resultant improvements in finish and appearance.

Friction Welding: Operation is based on heat produced by friction of rapidly moving parts under high pressure which is sufficient to cause fusion or bonding of the parts. In the initial tests in the development of this process, the parts were held and rotated in a lathe modified to incorporate the application of pressure.

Foreign materials such as scale and impurities are removed by friction and plastic deformation of joined pieces. Metal is plastically deformed and forms a reinforcement as a collar or bead. A variety of materials has been welded such as low-carbon and medium-carbon steels, free-machining steel, stainless steels, cast iron, brass, aluminum, and titanium, in addition to dissimilar metals such as brass to steel, brass to cast iron, and cast iron to copper. Limitation of this process at the present time is to parts that are cylindrical in shape and can be rotated.

Some inherent advantages of the friction-welding process are low cost of power requirements and high speed of operation. The process has interesting possibilities for special applications to production welding of simple sections because of low initial capital investment.

Thermo-Pressure Welding: This process can be considered in the field of solid-phase welding. Parts to be welded are under continuous pressure and the metal is heated until complete or partial plastic flow is obtained. Success depends on the cleanliness of the surfaces under pressure and the application of heat to produce a true pressure weld. With the thermo-pressure process, it is possible to weld metals to semiconductors and to other metals which would be difficult to join by fusion welding. Pressure ranges from 5000 to 10,000 psi and temperature from 392 to 572 F.

Duration of pressure is important, and the time at pressure may vary from 5 sec to 10 min. This welding process has found applications particularly in the joining of semiconductors to metals like germanium and silicon and may solve many of the problems related to making contacts to small areas without using chemical fluxes.

Diffusion Bonding: This process is defined as a joining method in which metals are heated to temperatures below their solidus temperature and held under pressure

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for some length of time. No liquid phase is formed and bonding occurs by movement of atoms or intermetallic compounds across the interface on the surfaces where intimate contact occurs.

At the present time, diffusion bonding has been investigated only for certain types of metal combinations such as gold and copper, gold and silver, nickel and copper, aluminum and gold, gold and nickel, and iron and nickel.

In the operation, intermetallic compounds are formed at the diffusion zone between metals to be joined. For some of the bonding operations, a plating of nickel, gold, copper, or other metals is first deposited on the surfaces. After plating, parts are joined by applying pressure and heat. Bonding temperatures are generally below 1000 F and pressure may range from 4000 to 8000 psi. Time for diffusion bonding varies from 20 min to 3 hr. During bonding it also may be necessary to use inert gas to prevent oxidation of the surfaces.

Diffusion bonding may find some important applications in welding special alloys where conventional processes are not suitable. Since temperatures are low, previous heat treatment is not altered, and distortion and cleanliness can be controlled.

Fusion Welding

Fusion welding includes a group of related processes in which heat is of primary importance in obtaining the coalescence of metal. The source of heat may be electrical, from some chemical reactions, or from the combustion of gases and solid fuels.

Electroslag Welding: This is one of the most recent developments in fusion welding and was reported in Russia. Fusion of the electrode wire and parent metal takes place in and under a molten slag bath covering the metal bath from which the weld is formed. The electrode wire or wires are immersed in the liquid slag. This process is used primarily for welding heavy sections and can be used for welding plates ranging in thickness from 2 to 12 in. or more.

The process can be most readily adapted for welding vertical butt joints in heavy weldments, but also can be used for welding of girth seams in heavy-wall cylinders and building up large surfaces with weld deposit. For making vertical butt joints in heavy plates, a number of electrode wires can be used simultaneously. In some applications, the wire can be oscillated back and forth so that the weld is uniformly deposited throughout the entire groove section. For making the vertical butt joints, the ends of the groove are enclosed by water-cooled copper plates so that the slag is confined in the weld area. These plates are moved upward as the deposition of metal progresses during the welding operation.

One of the advantages of this process is the high metal deposition rate which may be as high as 45 lb per hr. Another advantage is the higher thermal efficiency compared to that of the true arc-welding efficiency of the submerged arc-welding process. It is claimed that carbon steels, certain types of low-alloy high-strength steels, and stainless steels have been welded successfully with this process in Russia.

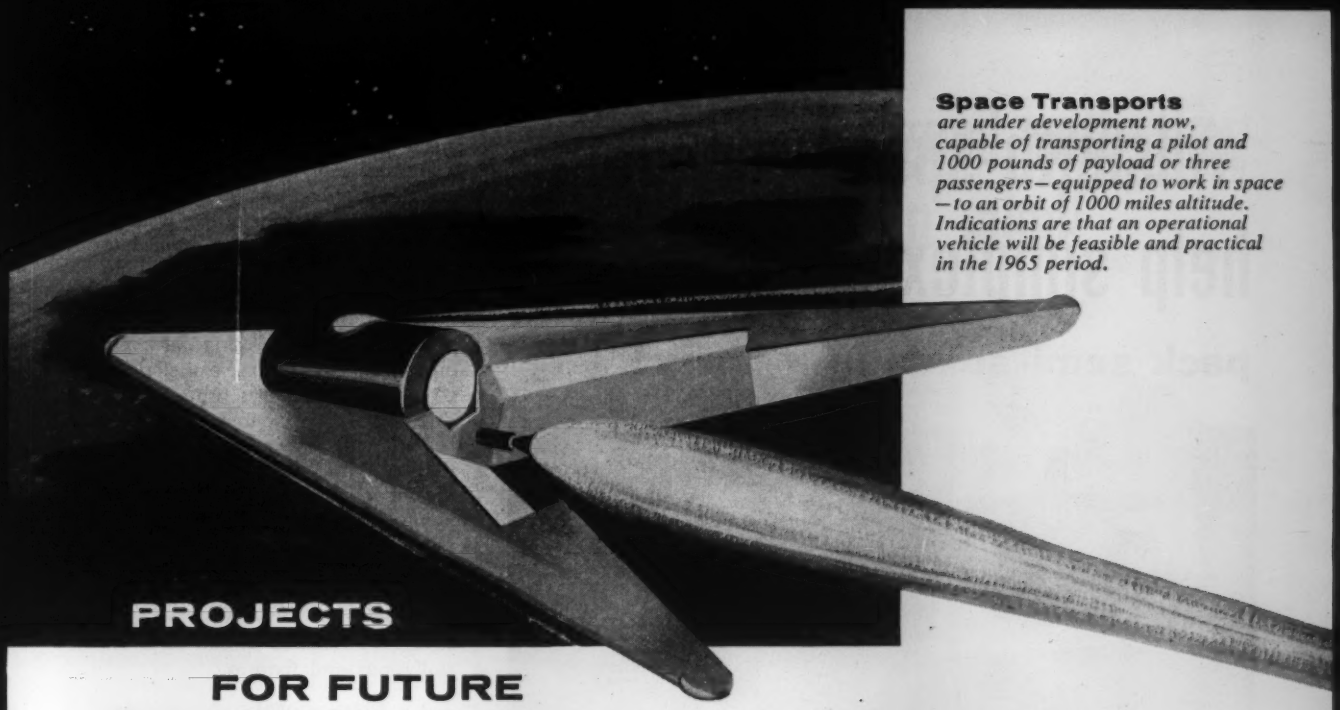
One limitation of this process is the large heat-affected zone area adjoining the weld and the coarse volumnar structure of the weld-metal deposit. Recommendations have been made to heat treat the weldments by a normalizing type of postheat treatment to refine grain structure. On very large weldments this would be a costly operation, and problems of distortion have to be considered. The process is still so new in this country that its application for industrial use may require further investigation.

Electron-Beam Welding: This is a relatively new process, and the principle of operation is based on the impingement of electrons on the workpiece in a high vacuum. Electrons are emitted from a tungsten wire filament, and are given a high degree of acceleration and velocity by a high-voltage potential between the cathode and anode. The workpiece is the anode.

Basically, all of the various makes of electron-beam welders operate similarly, the exception being in the focusing features of the equipment. These may vary depending on whether the electron beam is directed by means of magnetic or electrostatic controls. Because a high degree of vacuum is necessary to obtain electron bombardment, the operation is safe from the standpoint of atmospheric contamination. There is no contamination from oxygen, nitrogen, or other foreign materials. Since the operation from a purely electronic point of view is possible only below 2×10^{-4} mm of mercury, the level of atmospheric impurities is less than one part per million. The best commercially available inert gases contain a level of 15 to 20 parts per million of contaminating impurities. Such high purity is one of the most distinctive advantages of this process over any other welding method that has been developed so far.

With electron-beam welding, the high temperatures developed vaporize some of the impurities in the parent material. The resultant weld is much cleaner than the original base material. An advantage of this process is the absence of an electrode or an arc, sometimes a source of contamination in close proximity to the welding area. It is also possible to build into these electron-beam welders an optical system for direct viewing or an indirect system that can be focused on the work area. Another significant advantage is that the most reactive and refractory metals can be welded without contamination. Investigations can be made now for the first time to study effects of welding temperature and alloying effects of fusion welding without encountering contamination either by gases or foreign materials. One of the outstanding characteristics of the process is the resultant deep penetration. Tests so far have indicated that it is possible to obtain a depth-to-fusion-width ratio of 2 to 1 which implies a high temperature gradient.

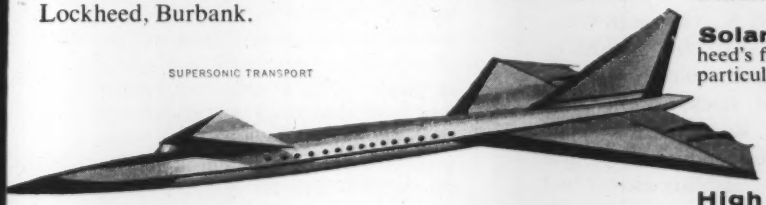
Reports by various investigators indicate that quality of the welds is excellent with freedom from porosity and slag inclusions. Mechanical strength and impact properties are claimed to be comparable or slightly better than welds made by the inert-gas tungsten-arc process. It is also claimed that grain size in the fusion zone and adjacent heat-affected areas is smaller for electron-beam welds than for welds



Space Transports *are under development now, capable of transporting a pilot and 1000 pounds of payload or three passengers—equipped to work in space—to an orbit of 1000 miles altitude. Indications are that an operational vehicle will be feasible and practical in the 1965 period.*

PROJECTS FOR FUTURE DECADES IN SPACE... *another Lockheed Progress Report to Engineers*

Plotting the nation's future space exploration projects requires the capabilities of a forward-looking company; one with vision, superiority in technical skills and advanced facilities. Lockheed, Burbank, long a leader in extending the science of flight, is placing its vast resources and accumulated knowledge into programs designed to provide major breakthroughs in the fields of: Basic and applied research; manned aircraft of advanced design; missiles and spacecraft. Shown here are artists' renderings of a few of these important projects. Such project diversification calls for high-level technical skill, offers genuine challenge to experienced engineers. At Lockheed these varied projects require engineers in many fields. Take advantage of this need. Go forward with a forward-looking company: Lockheed, Burbank.



Supersonic Transports—have held an important place in our thinking for the past several years. Extensive wind tunnel tests have been conducted on many design concepts, supplemented by exhaustive laboratory and structure studies. Lockheed is prepared to build an airliner that will travel at speeds in excess of Mach 3 at an altitude of 75,000 feet.

Infrared Systems studies are being conducted using an advanced method of detecting fast-moving missiles and high-speed aircraft. A new facility, which includes an advanced laboratory, with an infrared tunnel, for basic research and development of prototype equipment in this expanding field, has been set up to push Lockheed, Burbank, to the forefront in infrared study.

Vertical Take-off and Landing Projects—Lockheed, Burbank, is engaged in exploring the potential of VTOL projects on a very broad scale. Different VTOL features are embodied in each proposal. Considerable emphasis is being placed on VTOL "air recovery" vehicles, designed for air rescue and reentry missiles recovery missions.

Solar Radiation Studies—are being conducted at Lockheed's flight test radio station at Briar Summit, California, placing particular emphasis on solar flares as our contribution to the International Geophysical Year. We have already accumulated more than a quarter of a million images of the sun for analysis. In cooperation with other companies, we will determine the processes by which solar energy is released.

High caliber scientists and engineers are invited to take advantage of Lockheed's outstanding career opportunities. Openings now exist in: Electronics; aero and thermodynamics; propulsion; servo-mechanisms; materials and processes; structures and stress; operations research; research in optics, infrared, acoustics, magnetohydrodynamics, instrumentation, mechanics and hydraulics; mathematics; and in all phases of design. Write today to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 2307, 2400 North Hollywood Way, Burbank, California.

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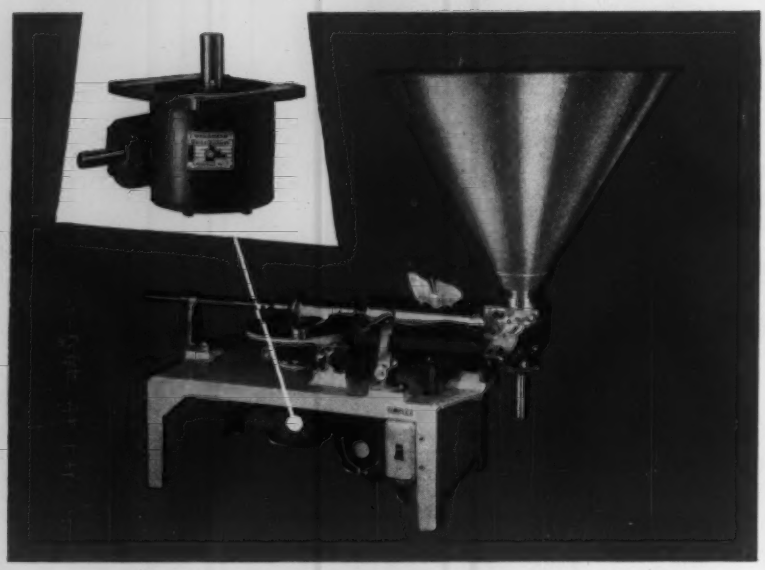
Circle 482 on Page 19

Winsmith speed reducers help simplex piston fillers

pack semi-solids in a hurry!



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made by other fusion processes. Tungsten, molybdenum, beryllium, tantalum, zirconium, and hafnium have been satisfactorily welded. The process can also be applied to some of the more common alloys such as stainless and carbon steel.

One of the disadvantages of this process when operating at very high voltages is the emission of x-rays which requires protection or shielding for personnel. Electron-beam circuits are involved and complicated, and require expert technicians to make necessary adjustments. The equipment must be made vacuum-tight for very low pressures, and all openings must be carefully designed to maintain the high vacuum. Welding of large structures requires special large installations and fixtures.

Arc Plasma: One of the newer achievements in recent years has been the development of arc-plasma type heating which produces temperatures from 10,000 to 30,000 F. Ionized gases are forced through a nozzle opening so that they have the appearance of a flame emanating from the end of the chamber. Plasma is defined as any material that is heated to extremely high temperature and is in the ionized conditon. It may consist of a hot stream of high-speed gases flowing at speeds from subsonic to ultrasonic. Energy transmitted is largely due to the ionization of atoms in the vapor and gases and to the dissociation of molecules which results in liberation of large amounts of thermal energy.

An application of the plasma torch is for spraying refractory materials. At the present time, the arc plasma is used primarily as a source of heat. While some equipment has been developed for metal and ceramic material deposition, the process has a vast potential for future applications for fusion welding of metals.

Designs of arc-plasma equipment have been developed and investigated which utilize carbon electrodes and water instead of gas as a stabilizing medium. An experimental unit of 10,000 kw capacity has been designed for special high-temperature application. One limitation of this process is the high-pressure blast effect developed in

the arc plasma causing the liquid metal to be blown away from the weld area.

Brazing

Brazing covers a group of welding processes where coalescence is produced by heating to suitable temperatures above 800 F. It requires filler metal having a melting point below that of the base metals. Filler metal is distributed between the closely fitted surfaces of the joint by capillary attraction. Flux may or may not be necessary depending upon the method of heating and metals joined. Significant improvements have been made mainly in the brazing alloys and heating methods.

One outstanding brazing achievement is the development of sandwich-type construction used on various parts of aircraft components. Materials can be any of the stainless steels, titanium alloys, and certain high-temperature alloys. The brazing operation can be performed in a number of ways such as furnace brazing with partial vacuum or an inert-gas atmosphere to prevent oxidation, and with graphite blocks to maintain proper dimensional stability and flatness. Parts are enclosed in a metal envelope hermetically sealed around the edges, and the entire assembly is placed in a furnace. Modifications may consist of heating the parts in a sealed envelope to the proper temperature and then inserting the assembly between two die blocks. Sufficient pressure is exerted to hold and maintain the flatness and shape of the sandwich construction.

Silver alloys containing small amounts of lithium for improved wetability have been developed. Other high-temperature brazing alloys include nickel-chromium-boron types. It is likely that further developments in brazing alloys and procedures will continue, and applications for joining light-gage metals will increase. The future appears promising for marked improvements in design for brazing, as well as for improved materials and techniques.

SAE paper 52S, SAE National Aeronautic Meeting, New York, April, 1959; 17 pp.

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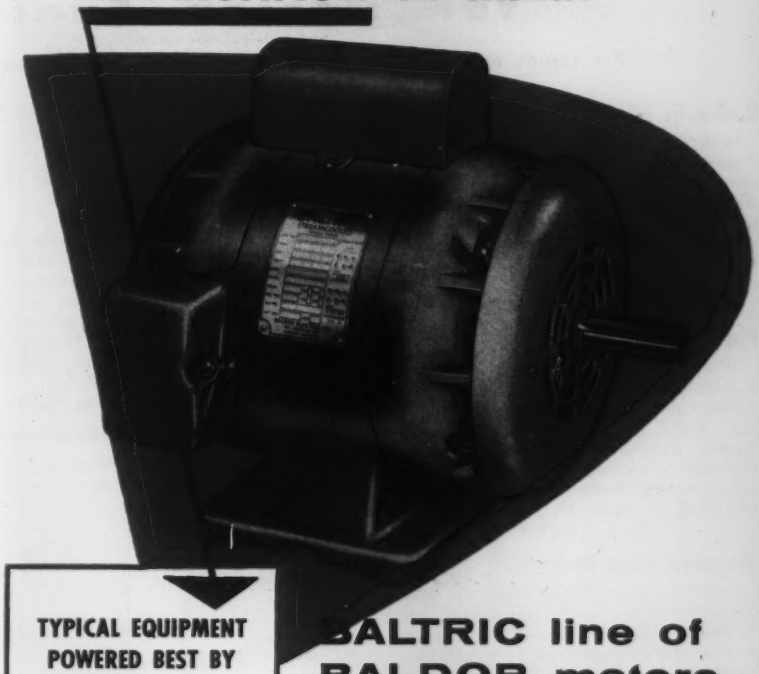

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Circle 484 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Hydraulic Filter

Design features of the line type hydraulic filter are presented on a data sheet. Its Monel wire mesh filter unit allows its use with any liquid. Specifications and a pressure drop graph are included. 2 pages. Capital Engineering & Mfg. Corp., 5837 S. Ashland Ave., Chicago 36, Ill. I

Circle 601 on Page 19

Portable Switches

Weathertight, corrosionproof pendant pushbutton station is one of the portable switches described and illustrated in Bulletin F49. Also described are several toggle, molded-to-cable, and standard pushbutton switches. 2 pages. Joy Mfg. Co., Electrical Products Div., 1201 Macklind Ave., St. Louis 10, Mo. I

Circle 602 on Page 19

Magnetic Tape Recorder

Features of the PS-200 magnetic tape instrumentation recorder are pointed out in Bulletin 55. This seven-channel magazine-loading transistorized recorder-reproducer weighs only 65 lb and operates on 250 watts of power. 8 pages. Precision Instrument Co., 1011 Commercial St., San Carlos, Calif. M

Circle 603 on Page 19

Self-Lubricating Bearings

"Powder Metallurgy Products" is title of illustrated bulletin which presents complete size and application information on an extensive line of self-lubricating bearings. Types covered include plain cylindrical and flanged, and spherical, single hub, and double hub self-aligning bearings. 6 pages. Johnson Bronze Co., 406 S. Mill St., New Castle, Pa. G

Circle 604 on Page 19

Clamps & Brackets

Engineering Design Manual No. 210G describes a complete line of standard clamps, line supports, brackets, and shims for all types of electronic, hydraulic, and mechanical harnessing. Indexed for quick reference, book contains preprinted sketch sheets to simplify design. 94 pages. TA Mfg. Co., 4607 Alger St., Los Angeles 39, Calif. L

Circle 605 on Page 19

Limit Switches

Heavy duty water and oiltight Snap-Lock limit switches which can be obtained in standard, neutral position, short travel, and push lever models are completely detailed in Bulletin EM-5912. Half-scale fold-out sheets enable the designer to trace the units directly onto layouts. Complete specifications are given on all models. 16 pages. National Acme Co., 170 E. 131st St., Cleveland 8, Ohio. F

Circle 606 on Page 19

Chain

Chain data Bulletin 59 is a guide to 17 types of welded and weldless chain. Actual size illustrations, recommended uses, and working load limits are some of the data given to aid in selecting the correct chain size and type for practically any job. 28 pages. S. G. Taylor Chain Co., Box 509, Hammond, Ind. J

Circle 607 on Page 19

Prefoamed Plastics

Chemical and physical properties of Nopcofoam, prefoamed, urethane plastics, are charted and detailed in comprehensive Bulletin US 459. Both polyester and polyether types of these flexible foams are covered. 16 pages. Nopco Chemical Co., Plastics Div., North Arlington, N. J. D

Circle 608 on Page 19

Adjustable-Pitch Sheaves

Offered in all popular A and B-section sizes and a new C-section size, Adjustex sheaves afford simplicity and economy to variable speed drive applications. Features of these adjustable pitch sheaves are presented in Bulletin 20B9125. 2 pages. Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. K

Circle 609 on Page 19

Magnetic Laminations

Precision-made high permeability transformer, magnetic head, servo motor, and special shape laminations are subject of Bulletin TB104. Characteristics of the laminations are charted. 4 pages. G-L Electronics, 2921 Admiral Wilson Blvd., Camden 5, N. J. E

Circle 610 on Page 19

Flexible Couplings

Posiflex miniature flexible couplings and shaft joints which compensate for shaft misalignment are detailed in illustrated bulletin. These power transmission components are suited for a wide range of uses. 4 pages. Fourdee, Inc., Box 6006, Orlando, Fla. O

Circle 611 on Page 19

Hydraulic Pumps

Extensive line of hydraulic pumps for diverse industrial and aircraft use is subject of illustrated Bulletin HP-1000. Specifications and performance data are included. 36 pages. Clark Equipment Co., Hydraulic Products Div., Benton Harbor 6, Mich. H

Circle 612 on Page 19

Semiprecision Bearings

Five types of semiprecision ball bearings, including split-race types, are covered in Catalog 59. Complete performance data, dimensional details, and application suggestions for these relatively low-cost bearings are shown. Modifications which answer specific design or end-use requirements are discussed. 24 pages. Freeway Washer & Stamping Co., 4911 Grant Ave., Cleveland 5, Ohio. G

Circle 613 on Page 19

Plastic Valves

Technology of plastic piping systems, including installation and coupling methods, pipe standards, and effects of 280 chemicals on five plastics used in Chemtrol valves is covered in Handbook C-159. Temperature and pressure chart for valves is included. 16 pages. Chemtrol, 10872 Stanford Ave., Lynwood, Calif. L

Circle 614 on Page 19

Hose Assemblies & Couplings

Application data, design information, and detailed specifications of medium duty hose assemblies and couplings are found in illustrated technical Bulletin 100. How to assemble reusable couplings is related. 36 pages. Eastman Mfg. Co., Manitowoc, Wis. K

Circle 615 on Page 19

Mechanical Seals

Range of process applications and limitations of Dura mechanical seals are related in technical Bulletin 480. Specifications are given for a wide variety of types and models. 20 pages. Durametallic Corp., 2104 Factory St., Kalamazoo, Mich. H

Circle 616 on Page 19

Carbide Bond Metal

Plymet, a metal for bonding carbide to steel, is self-fluxing and shock resistant. Bonded joints have a rupture strength of over 100,000 psi. Its application and instructions for use are found in illustrated folder. 4 pages. Powder Alloys Corp., 316 Colfax Ave., Clifton, N. J. D

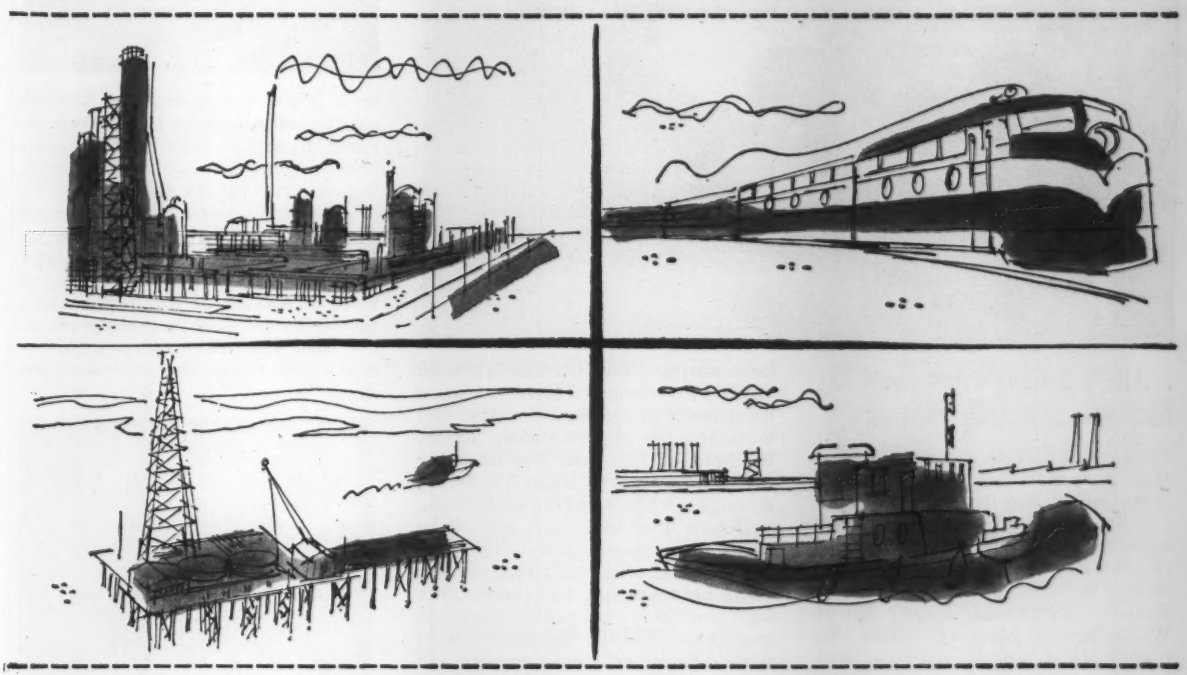
Circle 617 on Page 19

Heat Exchanger Tubing

Where Trufin integral finned tube should be used, how fins affect heat exchanger design, and a comparison of Trufin and bare tube exchanger costs are among contents of technical bulletin. Tube-to-Trufin conversion charts for various alloys are included. 20 pages. Calumet & Hecla, Inc., Wolverine Tube Div., 17200 Southfield Rd., Allen Park, Mich. H

Circle 618 on Page 19

FOR THE LONG RUN . . .



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Early in production, a Chromalox-heated hood is used in centrifugal molding of the launcher tubes.

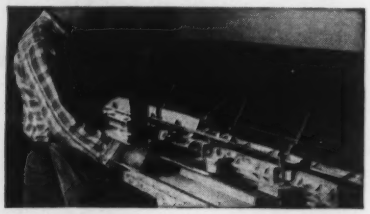
First, a rolled fibre-glass mat is placed inside the mandrel, which is then engaged in spinning motion at 800 rpm. After thermosetting resin has been sprayed into the mandrel, the hood is lowered into position for heat curing. The Chromalox type RAD Far-Infrared Heaters have a total capacity of 36,600 watts, and work reaches approximately 200°F. in about 45 minutes. The hood remains on a total of about 3½ hours, throughout the spinning operation.

Before final assembly, each tube must have steel "nut bars" and "guide bars" cemented to its interior. (Nut bars connect the three tubes into one assembly; guide bars guide torpedoes into the launcher tube.) After these parts are cemented in place, two Chromalox Tubular Heaters wired in series set the cement.

Mounted in a frame which holds them in the center of the tube for its entire length, the 240-volt, 2750-watt heaters are controlled by a Chromalox type AR Thermostat. A small fan attached to the end cap circulates heat within the tube and eliminates condensation.

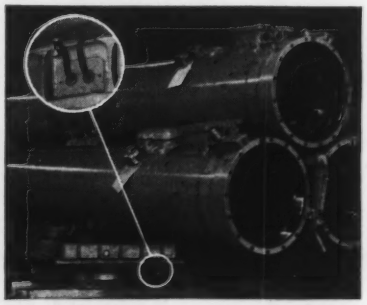
Next, four plastic quadrants are bolted to the tube interior, forming a liner to accommodate 12¾-inch torpedoes. To each quadrant are affixed two 101-inch Chromalox Flexible Woven Heaters.

After resin has been applied to the two channels in each quadrant, heaters are laid in place as shown below. The leads are then connected



to a power outlet and the heaters set the cement which bonds them in place. In action, these heaters maintain a protective 50°F. minimum temperature for the torpedo.

The closeup below shows two leads of a circular Chromalox Tubular Heater clamped in a groove around the launcher's swivel base. To prevent formation of ice in the joint between fixed and rotating parts of the base, this heater comes on automatically when the temperature drops below 50°F.



Plastic bottles, containing air at 2000 psi, provide pneumatic force to launch the torpedoes. Fabrication of these bottles, by the unique Apex filament winding process, involves still another Chromalox Heat application. After the plastic bottle has been formed around a Cerro-alloy ball mold, the alloy must be melted from the bottle's interior. Four sets of Chromalox Strip Heater Bands and a Chromalox Ring Heater provide booster heat on the steam-heated vat used for this purpose.

Perhaps one of these heaters, or one of the 15,000 other types, sizes and ratings of Chromalox Heaters can answer your need for heat. For personal assistance and specific recommendations, *Call your Chromalox Man for the Answers.* He's listed at the right.

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133 Clinton Ave. S.
Hamilton 6-2070

ST. LOUIS 1, MO.
C. B. Fall Company
317 N. 11th St.
Suite 1001
Chestnut 1-2433

SAN FRANCISCO 3, CALIF.
Montgomery Brothers
1122 Howard St.
Underhill 1-3527

SEATTLE 4, WASH.
Montgomery Brothers
911 Western Ave.
Main 4-7297

SYRACUSE 6, N. Y.
R. P. Smith Co., Inc.
2507 James St.
Howard 3-2748

WICHITA 2, KAN.
Fraser D. Moore Co.
Room 211 Derby Building
352 N. Broadway
Amherst 2-5647

EXPORT DEPARTMENT
1010 Schaff Building
Philadelphia 2, Pa.

Aluminum Hand Forgings

Aluminum hand forgings, subject of illustrated Brochure FO-810, provide data for proving or improving design of a part prior to making tools for die forgings. Another use is for low quantity items. Processing techniques, available shapes and sizes, and properties are covered. 20 pages. Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland, Calif. M

Circle 619 on Page 19

Tough, Hard Plastics

Cycolac acrylonitrile-butadiene-styrene polymers, available in molded parts, extrusions, and formable sheet, are suited for products requiring high impact strength, heat resistance, good electrical properties, and dimensional stability. Their properties are detailed according to various types. 8 pages. Borg-Warner Corp., Marbon Chemical Div., Washington, W. Va. F

Circle 620 on Page 19

Nameplates & Trim

A sample precision cast nameplate as well as complete information on the production capabilities of this company for engineering and making cast metal nameplates and decorative trim are included in Bulletin 3547. Fastening methods, typical users, and suggested applications are also listed in these fact sheets. 8 pages. La France Precision Casting Co., Philadelphia 45, Pa. E

Circle 621 on Page 19

Electric Motor Bearings

Catalog No. 258 is complete listing of electric motor bearings and precision bronze bars. Replacement bearings for leading makes of electric motors with cross-reference parts numbers are included, as is a progressive size listing. Properties of No. 72 bearing bronze used in motor bearings are covered. 48 pages. Bunting Brass & Bronze Co., 715-755 Spencer St., Toledo 1, Ohio. G

Circle 622 on Page 19

Adjustable Speed Drive

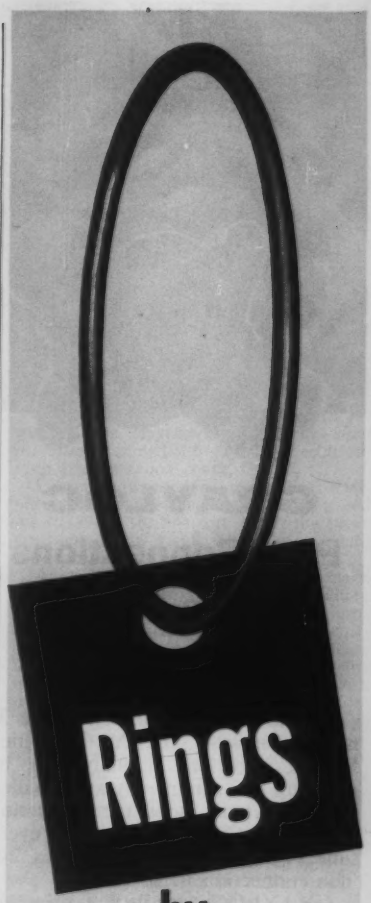
Adjustable speed and drive control problems in the ⅛ to 16-hp range with input speeds to 1800 rpm are discussed in Bulletin K-250. Presented are typical applications, methods and types of remote and automatic control, and available assemblies of the Speed Variator drive. 8 pages. Cleveland Worm & Gear Co., Speed Variator Div., 3300 E. 80th St., Cleveland 4, Ohio. F

Circle 623 on Page 19

Packings

Metallic packings, packing rings, materials selection data, piston rings, liquid pump packing, ring type seals, valve discs, and engineering reference data are chapter headings of comprehensive Catalog 49-59. Complete engineering, design, and application data are included. 52 pages. France Packing Co., 9925 Bustleton Ave., Philadelphia 15, Pa. E

Circle 624 on Page 19



by

LINEAR

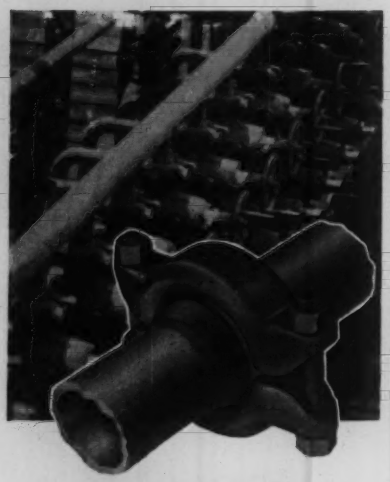
in low-compression-set Butyl . . . for sealing problems involving the non-flammable phosphate esters.

LINEAR . . . specialists in close tolerance molding in all of today's elastomers.

Call on LINEAR for assistance with all your seal problems.

PERFECTION IN RUBBER
LINEAR
LINEAR, Inc. STATE ROAD & LEVICK ST., PHILA 35, PA

Circle 487 on Page 19



GRAYLOC
Pipe Connections Make-Up In 3 Minutes

Unlike the 3-minute egg or the 3-minute car wash, GRAYLOC 4-inch Pipe Connections actually can be made up in 3 minutes by an unskilled laborer. What's more, the connection will test up to 10,000 p.s.i. every time. Two men can make-up a 24-inch connection in 15 minutes.

GRAYLOC, with its new principle in pipe make-up, can be broken out and re-made repeatedly with no wear or other damage to the connections and without replacement of the seal ring.

The GRAYLOC principle features flexible tapered lips of the seal which are angled slightly less than the mating hub. This forms a line seal which is changed to a surface seal as the connection comes together and the lips deflect. This design makes it possible for GRAYLOC to withstand full vacuum, high external pressure or extreme internal pressure.

GRAYLOC has practical applications in missile, chemical, petroleum, and atomic energy processes.

For additional information, write, wire or telephone Gray Tool Company.

GRAY Tool Company

P. O. BOX 2291 HOUSTON, TEXAS
REpublic 4-1641 8805

Circle 489 on Page 19

HELPFUL LITERATURE

Plastics

Properties and typical industrial applications of 13 major plastic families are compared in booklet "Getting Acquainted with Plastics." Included are acrylic, Implex, nylon, Teflon, polyethylene, flexible and rigid vinyl, butyrate, and others. 4 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. H

Circle 625 on Page 19

Blind Rivets

Type MS aluminum self-plugging blind rivets in protruding and countersunk head types are described in Form 8-457. These easily installed fasteners are made in a wide range of sizes. 4 pages. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 626 on Page 19

Thread Inserts

New line of Min.O.Dee Lok-Thred inserts for soft metals and plastics is introduced in illustrated catalog. Offered in through, pipe, blind, and special tapped styles, inserts are fully detailed. Design data are included. 8 pages. Lock Thread Corp., 2832 E. Grand Blvd., Detroit 11, Mich. H

Circle 627 on Page 19

Nickel Tubing

Chemical composition, physical constants, and mechanical properties of four types of seamless nickel tubing are tabulated in Bulletin CM-359. Outside diameters range from 0.012 to 1.125 in. 4 pages. Superior Tube Co., 1578 Germantown Ave., Norristown, Pa. E

Circle 628 on Page 19

Adjustable Speed Drive

"Adjustable Speed Drive Equipment for Calendering" is title of Bulletin GEA-6910 which describes how to combat the cost-profit squeeze with a planned program of drive modernization. Details of various types of all-electric adjustable-speed drives, motors, and controls are outlined. 8 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 629 on Page 19

Industrial Batteries

A new line of storage batteries which boosts the work capacity of electric industrial trucks by as much as 45 per cent is covered by Form 6230. Features of Exide-Ironclad batteries rated up to 720 ampere-hours in 21-plate constructions are explained. 8 pages. Electric Storage Battery Co., Exide Industrial Div., Rising Sun & Adams Avenues, Philadelphia 20, Pa. E

Circle 630 on Page 19

Fluid Power Components

Condensed specifications on fluid power components such as pump generators, motor converters, valve controls, and cylinder converters are contained in Bulletin 100-P4. 4 pages. Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown 1, Ohio. G

Circle 631 on Page 19

IT PAYS TO HAVE HUBBELL GOOD CONNECTIONS

Manufacturers of Cold Headed Fasteners Since 1888

Hubbell has the capacity to produce and deliver on time the finest quality standard or special fasteners in the quantity required up to a maximum diameter of 3/8". This statement is backed by the facilities listed here and supported by over 70 years' experience in cold heading.

Each operation is quality controlled to insure high quality and precision.

COLD HEADING

SLOTTING

Mass production is maintained without sacrificing accuracy or quality.

THREAD ROLLING

TURNING POINTING

The use of our engineering service offers the ultimate in engineering know-how.

DRILLING TAPPING

Prices and delivery on request. Simply send blueprint and/or sample of the item.

PLATING HEAT-TREATING

QUALITY CONTROL

HARVEY HUBBELL, INCORPORATED

Machine Screw Dept. Bridgeport 2, Conn.

Circle 490 on Page 19

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **A plastic for potentially hazardous locations**
- **Material for a non-warping switch**
- **More design freedom in metal castings**

Canopy retards fire

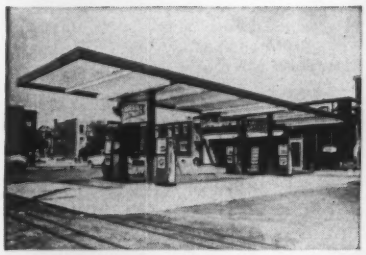
Good product ideas seem to work almost anywhere.

Take, for example, this plastic gas-station canopy. So far as we can tell, the idea of cool, light-diffusing canopies over the gas pumps started in the South, where it would seem to be a natural.

However, the canopy you see here is in Canada. It does most of its work in winter, when it may have to hold up the weight of five feet of snow and ice.

The marketing strategy is sound. A motorist doesn't mind so much getting out of his car in bad weather when he's protected overhead; and the attendant, too, is likelier to provide that extra bit of service.

There's something else that's different about this canopy. It doesn't support combustion, because it's made with Hetron® self-extinguishing polyester resin. A fire starting at a pump won't spread along the canopy to other pumps or to the station building.



If it weren't for self-snuffing Hetron, there'd be few places where a good idea like this could operate. Fire retardance is chemically locked into the resin, not added later at the expense of strength. The resulting combination of structural properties gives you something unique on which to base *your* new-product ideas.

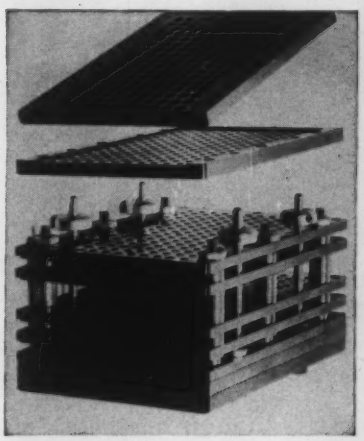
If you'd like to know more about Hetron resins, let us send you the complete technical data file, together with names of leading fabricators in this country and Canada who can make U/L-listed panels and custom-molded shapes for you.

Less dough for this "bread"

Needed: a dimensionally stable material for the "bread" in this sandwich-like multiple switch assembly (above right).

Why dimensionally stable? Because each of the seven "slices" in the sandwich has 187 holes that must line up with matching holes in the other plates.

What low-cost insulating material would hold alignment without risk of moisture absorption and warping? Could



holes be *molded*, rather than drilled, to the required accuracy? Would this save money?

The material recommended by the custom molder was a fast-curing Durez compound with good moldability and excellent dimensional stability. This material does everything the designers want it to do. Its exceptionally good mold release facilitates the low-cost molding of holes. In addition, numbers and letters which were formerly silk-screened on the plates are now molded-in for extra savings.

Result: a smooth-functioning, non-warping switch, produced with the utmost economy. It's just one more proof of the wide, wide spectrum of design requirements you can meet at low cost with Durez phenolics (and often *only* with phenolics). Want more information on these versatile molding compounds? Just check the coupon for a bulletin on Durez materials.

Castings – can do

Don't back off from a complex metal shape just because "it can't be done."

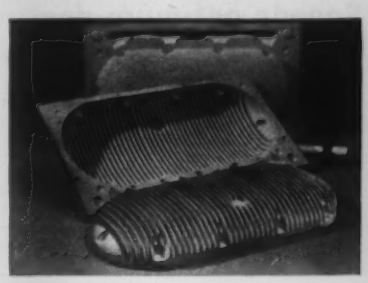
Instead, talk to your foundryman. He may have a surprise up his sleeve—*shell molding*. It saved the day for the aluminum-alloy gearbox cover, below.

Designers wanted as many heat-dissipating fins as possible; they compromised on 40. Even so, fins tore when the piece was poured in sand. Three men could produce only 20 good castings a day.

A switch to shell molding has made the casting economically feasible. Three men now turn out 70 per day. Dimensions are much more consistent from one casting to the next. As a bonus, engineers found they could squeeze two more fins into the design to get higher efficiency than they first believed possible.

What about cost? Shell-molded castings sometimes cost more *per pound* than regular castings. But they often save you far more than the difference—by reducing machining and finishing time and by speeding assembly.

Like to know how these better castings are made with the help of Durez foundry resins? We'll gladly send you the new 36-page "Durez Guide to Shell Molding" if you check the coupon below.



For more information on the Durez materials mentioned above, check here:

- ☐ Hetron fire-retardant polyester resins (50A)
- ☐ General bulletin on Durez materials (Bulletin 400)
- ☐ "Durez Guide to Shell Molding" (36-page bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ PLASTICS DIVISION

507 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle 491 on Page 19

LGP-30

ROYAL PRECISION

Here is the low-cost, desk-side electronic digital computer you need for general design and system optimization

Speeds optimum design of new products and equipment!

Operating from any convenient wall outlet, the compact, powerful LGP-30 will today furnish you with high-speed electronic computation wherever you need it . . . will eliminate tedious hand calculations . . . help you free up more creative time.

Combining large memory (4096 words) and stored-program operation, the LGP-30 gives you twice the capacity of any computer in its class, yet is by far the easiest to program in basic machine language. Simplified controls can be operated with only minimum computer experience. Answers are printed out directly—require no deciphering. Best of all, even with these many unique advantages, the LGP-30 is the lowest-priced complete computer you can buy. What's more, auxiliary high-speed input—output equipment is available for system expansion.

No expensive installation or air-conditioning required. Customer training is free. An extensive library of programs and sub-routines is available—as well as membership in an active users organization. Sales and service facilities are maintained coast-to-coast.

For further information and specifications, write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y. In Canada: The McBee Company, Ltd., 179 Bartley Drive, Toronto 16.

ROYAL McBEE · *data processing division*

Circle 492 on Page 19

Transmission Machinery

Review of the Dodge line of power transmission machinery presented in Bulletin A-706 is brief but comprehensive. Newest products featured are Flexidyne dry fluid drives and Para-flex flexible cushion couplings. Steel conveyor pulleys, roller chain drives, shaft couplings, and the Dyna-V line of V-belt drives are covered along with other products. 8 pages. Dodge Mfg. Corp., Mishawaka, Ind. J

Circle 632 on Page 19

Products Literature

Available literature on company products includes numerous brochures, engineering reports, and specification sheets on precision gears and breadboards, clamps, clutches and differentials, modular test equipment, drive test tables, turntables, gyro test sets, and various test consoles. Material is enclosed in a bulletin on research and development, manufacturing, and lab facilities. Sterling Precision Corp., Instrument Div., 17 Matinecock Ave., Port Washington, N. Y. D

Circle 633 on Page 19

Long-Stroke Seals

Development, operation, applications, selection, specifications, and engineering data on the Bellofram seal are contained in Bulletin BF200-3. This long-stroke, deep-convolution, constant-area diaphragm is free-positioning within its stroke and is responsive to small pressure changes. 20 pages. Bellofram Corp., Blanchard Road, Burlington, Mass. B

Circle 634 on Page 19

Cams & Shafts

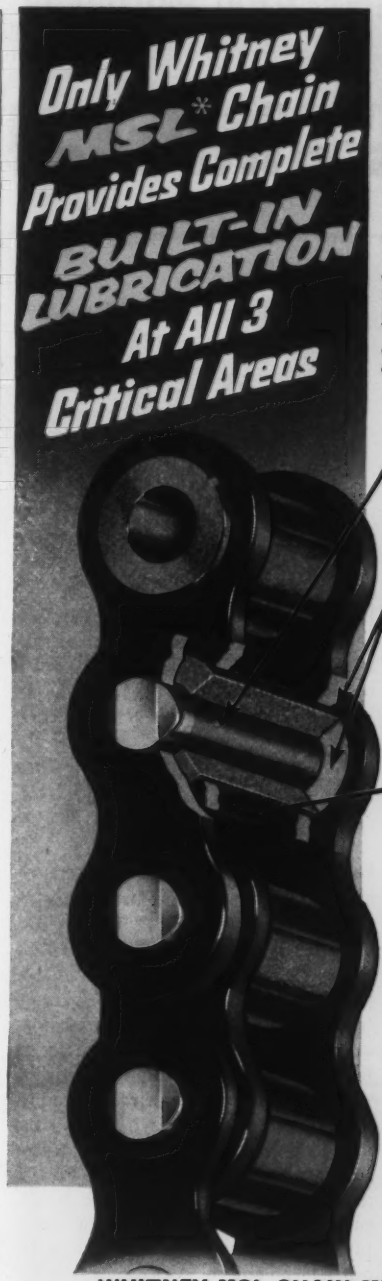
Basic metallurgy and important engineering properties of Meehanite metal used in cams, camshafts, and crankshafts are described in illustrated Bulletin 39. Examples of parts produced by various manufacturers are detailed. 12 pages. Request on company letterhead from Meehanite Metal Corp., 714 North Ave., New Rochelle, N. Y. D

Potentiometers

Specification sheets for standard wirewound single and multiturn precision potentiometers are found in illustrated Catalog 202. Facilities for designing and producing special tolerance wire-wound and special nonlinear potentiometers, and precision machinery are described. 100 pages. Request on company letterhead from Spectrol Electronics Corp., 1704 S. Del Mar Ave., San Gabriel, Calif. M

Welding of Aluminum

Techniques of welding aluminum using Aircomatic gas-shielded metal-arc and Heliweld tungsten-inert gas processes are covered in detailed handbook. It has 100 photographs, charts, and detailed diagrams of equipment and techniques. Application data, power supplies, and safety practices are among subjects. 116 pages. Request on company letterhead from Air Reduction Sales Co., 150 E. 42nd St., New York 17, N. Y. D



Whitney MSL Chain is lubricated for life by oil-impregnated, sintered steel bushings —an exclusive development of Whitney Research. With this development, Whitney solves a basic chain problem . . . more damage is caused by faulty chain lubrication than by years of normal service. Pressure and heat cause built-in lubricant to expand and flow from bushings, providing a constant supply of lubricant to every working part of the chain. When drive stops, bushings re-absorb oil, ensuring a permanent oil supply for the life of the chain. By solving the lubrication problem, and because of other important design advantages, Whitney MSL Chain outlasts conventional chain as much as 5 to 1 in severe operating environments.

Critical Area 1

PIN—Protective film of oil completely lubricates the live bearing area between pin and bushing, minimizing wear by reducing metal-to-metal contact.

Critical Area 2

PLATES—Whitney oil-impregnated sintered steel bushings extend beyond surface of inside plates to: act as lubricated thrust bearings, control clearance, and provide an oil cushion between plates, eliminating plate galling and seizing frequently caused by misalignment of sprockets.

Critical Area 3

SPROCKET ENGAGEMENT — Oil film on exterior surface of Whitney MSL Sintered Steel Bushings provides constant lubrication between sprocket teeth and chain. Whitney MSL Chain requires no rollers, as the tough oil film on the bushing surface provides smooth sprocket engagement, cushions impact and reduces drive wear.

Whitney oil-impregnated bushings—developed through continuous Whitney Research—are produced exclusively by Whitney to assure MSL Chain users of highest quality and reliability.

Inherent material characteristics of Whitney Sintered Steel Bushings, plus bushing configuration that provides greater contact area between bushings and links, permit high interference fit, which pre-loads links and gives maximum fatigue resistance.

Controlled clearance between plates promotes self-cleaning action.

WHITNEY MSL CHAIN MEETS ASA STANDARDS

All essential dimensions of Whitney Standard and Extended Pitch MSL Chain conform fully to ASA Standards, making it completely interchangeable with any similiar pitch ASA standard chain, simplifying specification for new equipment, or as a replacement for existing drives.

Whitney MSL Chain is carried in stock by Distributors in all parts of the United States, for prompt delivery.

*Maximum Service Life

Whitney CHAIN COMPANY

Advanced Design Is a Whitney Tradition

A Subsidiary of Foote Bros. Gear and Machine Corporation

302 WEST HAMILTON STREET — HARTFORD 2, CONNECTICUT

Circle 493 on Page 19

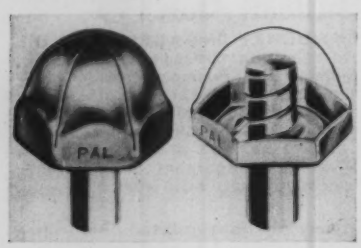
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Self-Threading Nuts

are available in acorn type

Acorn-type CST self-threading nuts form deep, clean threads while tightening on unthreaded studs, rod, wire, or rivets of aluminum, zinc, steel, brass, or plastic. They are presently available for 1/8 and 3/16 in. diam. Tempered spring-steel nuts have a decorative dome shape that covers ends of studs or rods. High tensile and torque values are provided, while resilient spring forces assure a strong, vibra-



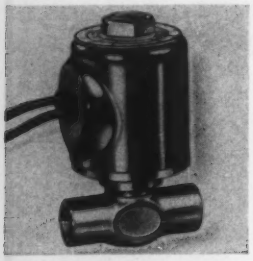
tionproof grip, whether seated or unseated. **Palnut Co.**, 75 Glen Rd., Mountainside, N. J. D

Circle 635 on Page 19

Solenoid Valves

miniature units are two and three-way types

Miniature, small-ported, solenoid valves have ac shading coils of fine silver, fully rotatable coil housings for electrical connections from any angle, ability to operate equally well in any mounted position, and broad selection of pipe and tube connections. Direct-acting valves have brass or stainless-steel bodies. Designated Series 90 for two-way and Series 95 for three-way types, valves meet a variety of application requirements. Orifice sizes for two-way types range from 1/32 to 1/8 in., with differential pressure ratings to 2000 psi. Three-way types



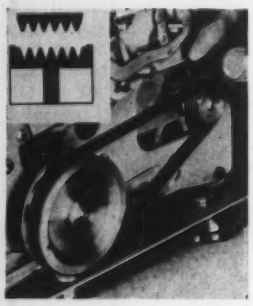
have orifice sizes from 1/32 to 1/16 in., with differential pressure ratings to 300 psi. **Hoke Inc.**, 91 Piermont Rd., Cresskill, N. J. D

Circle 636 on Page 19

Flexible V-Belts

operate over sheaves as small as 0.8 in. pitch diam

Especially designed for high-speed, small-pulley, power - transmission applications, Poly-V "J" V-belts are thin and flexible. They operate over sheaves as small as 0.8 in. pitch diam, and pitch lengths range from 8 to 98 in. Belts are single, endless rubber units with a series of parallel V-ribs molded lengthwise around inside circumference. Sheave grooves mate with belt ribs, and load is evenly distributed across full width of drive member. Belts are recommended for belt-drive applications except where variable-pitch or adjustable sheaves are required or where positive speed ratios are essential. They are also



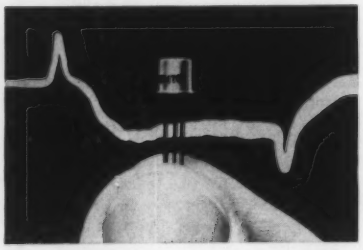
recommended for applications to speeds of 10,000 rpm. **Manhattan Rubber Div., Raybestos-Manhattan Inc.**, Passaic, N. J. C

Circle 637 on Page 19

Miniature Transistor

has switching speed of 25 millimicrosec

Diffused-base, subminiature silicon switching transistor, known as 2N702, features typical total switching speeds to 25 millimicrosec and guaranteed dc beta range. Transistor is produced by gaseous-diffusion process which provides inherently high performance, outstanding reliability, extreme ruggedness, and high dissipation. Unit provides guaranteed dc beta spread of 15 to 45 and maximum collector cutoff current of 0.5 mu amp. Transistor is packaged in subminiature



JEDEC-outline, TO-18 case. **Texas Instruments Inc.**, P. O. Box 312, Dallas, Tex. P

Circle 638 on Page 19

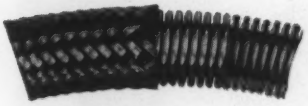
Quick-Disconnect Couplings

for liquid oxygen are self-sealing

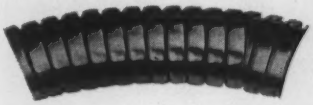
No. 321000 low-passage, self-sealing couplings consist of two single liquid-oxygen, quick-disconnect units incorporated into one grip assembly. They can be coupled and uncoupled with one-hand operation. The dual-passage couplings are constructed of corrosion-resistant ma-

Whatever your problem in flexible hose connections,

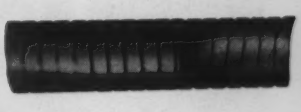
call the Man from Anaconda Metal Hose



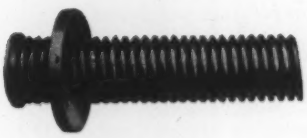
Seamless: Of tin bronze (98¾% copper, 1¼% tin)—also corrugated stainless steel—in sizes ⅛" through 4" I.D. For conveying fluids, chemicals, etc., under conditions of flexure or vibration and to allow for misalignment. Reusable (mechanical type), soldered or welded fittings.



Stripwound: Constructed from brass, bronze, aluminum, galvanized or stainless steel. Sizes ½" through 8" I.D. A rugged type of hose for general service as steam, oil, water, particularly where the hose is handled manually. Fittings: soldered or heatproof (packed-on).

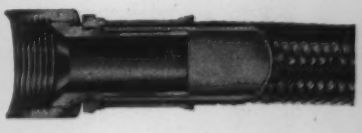


Type UI: Interlocked unpacked hose in galvanized steel, stainless steel, aluminum, etc. Sizes through 8" I.D. For ventilating ducts, dust collection, engine exhausts, exhausts at grinding machines, bottle chutes, drain lines, protective casing for flexible hose assemblies.



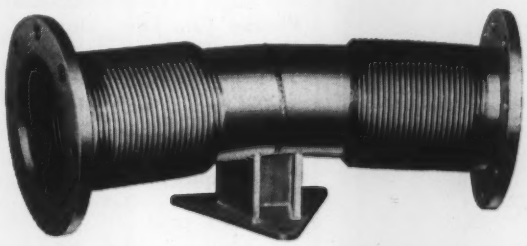
Diesel: Heavy-duty steel exhaust and air intake hose. Sizes 2" through 16" I.D. Designed for rugged, heavy-duty use. Helical corrugations with open or closed pitch. Also in stainless steel (type Y-21) for corrosive applications.

Flexpipe: Takes up travel in piping, connects misaligned ports, dampens noise and vibration in piping. Standard sizes and lengths. Available in bronze, stainless steel, steel; in sizes ¼" through 16" I.D. with NPT fittings, flanges or welding nipples.



Teflon* Anaconda flexible connectors of Teflon with stainless steel wire braid for use with pipe sizes from ⅛" through 1¼". Available in a wide variety of standard hose assemblies complete with fittings.

*Teflon is a DuPont trademark for its fluorocarbon resins.



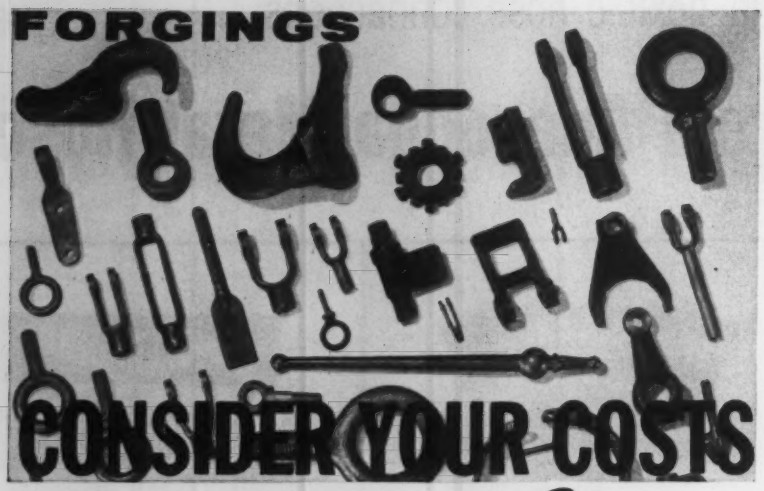
AX Tubing: Large diameter tubing for big, tough jobs. Available in Type 321 Stainless Steel, and other metals and alloys. Sizes from 4½" through 14" I.D. Designed to handle axial and lateral movement—while conveying large volumes of liquids or gases—for bulkhead seals, etc.

FREE TECHNICAL SERVICE. Anaconda Metal Hose specialists are constantly working with design engineers on special flexible connectors and hose to meet new problems. Having broad experience working in stainless steel, other steel alloys, Monel, copper alloys, aluminum, and Teflon, they can save you considerable time and money in designing the flexible connector best suited for any of your jobs.

Our specialists are available to you through Anaconda Metal Hose representatives in leading cities—see listing "Metal Hose" in the Yellow Pages. Or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. 5012D

ANACONDA® METAL HOSE

Circle 494 on Page 19



...SAVE ON A MODIFIED STOCK FORGING FROM *Cleveland*

Cleveland Forge Works . . . Stocks over 350 industrial forgings, tooling costs eliminated
Cleveland Forge Works . . . Finish-machines to your specifications
Cleveland Forge Works . . . Modifies stock forging to your design
Cleveland Forge Works . . . Offers broad facilities in forging, machining, and finishing from a single source

For catalog 19-A and complete facility information, write *Forge & Fittings Division, H. K. Porter Company, Inc., Cleveland 4, Ohio.*

FORGE & FITTINGS DIVISION PORTER **H.K. PORTER COMPANY, INC.**

PORTER SERVES INDUSTRY with 12 DIVISIONS including: Thermoid, Delta-Star Electric, National Electric, Riverside-Alloy Metal, Refractories, Connors Steel, Vulcan-Kidd Steel, Forge and Fittings, Disston, Leschen Wire Rope, Mouldings, and H. K. Porter Company (Canada) Ltd.

Circle 495 on Page 19

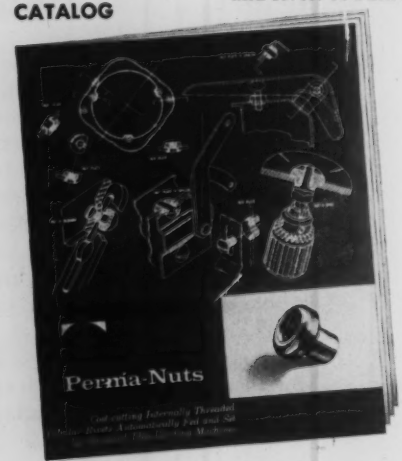
ATTACHMENT and FASTENING

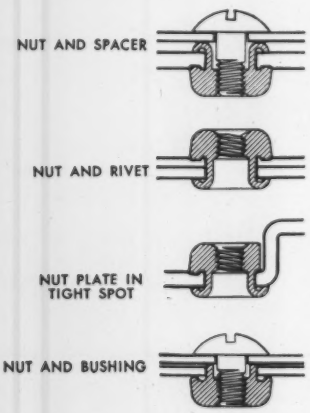
PROBLEM SOLVER

Applied with standard TRS riveting machines

Solve design problems with PERMA-NUTS and get the speed and economy in production that goes with automatic feeding and setting of standard tubular rivets. An important advantage of this unique combination nut and rivet! A built-in "lock washer" feature is another.

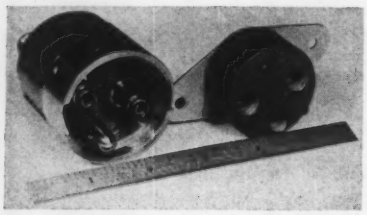
WRITE FOR CATALOG





TUBULAR RIVET & STUD CO., *Quincy 70, Mass.*

terial, and sealing members are either Teflon or Kel-F. Visual aids are provided to indicate that coupling is locked in detent engagement, and thrust bearing in disconnect half of unit reduces operating torque. Connecting or disconnecting can be accomplished



without any external leakage even when cryogenic system is pressurized. **Essex Mfg. Co. Inc.,** 8213 Gravois Ave., St. Louis 23, Mo. I

Circle 639 on Page 19

Molding Compound

has excellent low-temperature toughness

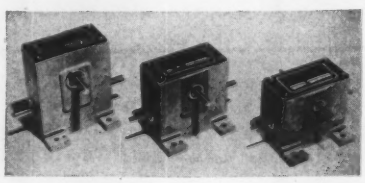
First of a series of polyethylene molding materials based on new copolymer, and developed especially for housewares applications, DPD-7365 has extensive use in a variety of other injection-molding applications. Compound has outstanding low-temperature toughness qualities, withstanding temperatures down to −10 F without shattering. Other qualities of DPD-7365 include long flex life, superior stress-cracking resistance, excellent surface gloss, broad molding latitude, and high rigidity. **Union Carbide Plastics Co., Div., Union Carbide Corp.,** 420 Lexington Ave., New York 17, N. Y. C

Circle 640 on Page 19

Speed Reducers

for torques to 350 oz-in.

Improved precision speed reducers are equipped with precision ball bearings or oilless bronze bearings. Designed for torques to 350 oz-in. in ratios from 1:1 to 360:1, units



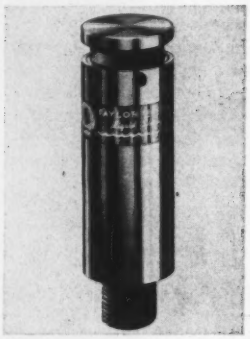
are available in 1/8, 3/16, and 1/4-in. shaft sizes. Range of over 175 different sizes and ratios is available from stock. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 641 on Page 19

Liquid Spring

is short-stroke, high-force unit

Model 1028 liquid spring, using liquid compressibility, is only 1 1/4 in. in diam by 3 1/2 in. long and provides a preload from 500 to 5000 lb. The short-stroke, high-force spring can also be a shock absorber to relieve excessive loads on structures or tools. Spring force increases 200



lb per 0.0001-in. stroke, plus damping forces of 6000 lb maximum and energy absorption of 1500 lb-in. **Taylor Devices Inc.**, 188 Main St., North Tonawanda, N. Y. N

Circle 642 on Page 19

Miniature Switches

plastic units are available in expanded line

Line of precision snap-acting switches now consists of 19 units in Series 5200. Ten models, with actuating button in center position, cover operating force range of 3 to 20 oz. They are qualified to basic snap-action switch specification MIL-S-6743 and vibration requirements of MIL-E-5272A, Procedure II. Additional line switches, with actuating button in off-center position, feature extremely low operating forces. Furnished with pin, integral-wire, or flat-leaf actuators, they cover operating force range of 2.5 to 60 gm. All Series 5200 switches have electrical terminals

You can solve many problems better and at lower cost with DIAMOND Roller Chain

another **BIG JOB** *calls for dependable*

DIAMOND®

ROLLER CHAIN

Four 2" pitch DIAMOND Roller Chains insure smooth, dependable operation in this counter-weight application.

◀This 40-foot high, 525,000-pound Vertical Boring and Turning Machine built by Morton Manufacturing Company of Muskegon Heights, Michigan, uses DIAMOND Roller Chains on the counter-weights.

DIAMOND Roller Chain assures long trouble-free life, efficient service and low-cost maintenance in every type of roller chain application.

When you need chain, specify DIAMOND. Write now for catalog containing complete information on DIAMOND Roller Chains and Sprockets. Engineering service is available.

DIAMOND CHAIN CO., INC.

A Subsidiary of American Steel Foundries

Dept. 435 • 402 Kentucky Ave., Indianapolis 7, Indiana

Offices and Distributors in All Principal Cities

DIAMOND ROLLER CHAINS

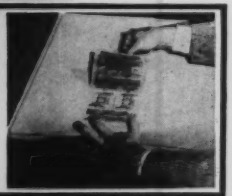
Circle 497 on Page 19

are you spending $12.00 for a one cent job?

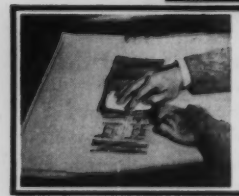
If you're duplicating drawing details, you're squandering precious hours of costly drafting time. STANPAT, the unique tri-acetate that is pre-printed with your standard and repetitive blueprint items, cuts time involved from 3 hours to 15 seconds! Figured at current pay rates, this means a $12 job at less than one cent . . . the STANPAT way. Easily transferred to your tracings by an adhesive back or front, STANPAT relieves your engineer of time-consuming and tedious details, freeing him to concentrate on more creative work.

here's how simple the STANPAT method is!

PEEL the STANPAT from its backing.



PLACE the STANPAT into position on the tracing.



PRESS into position . . . will not wrinkle or come off.

STANPAT is available in two types of adhesive backs:

- Rubber base for standard drafting and tracing papers
- Resin base to prevent leaching for papers that contain oils

But whatever the application may be, there's a STANPAT product for your specific needs. For further information and technical assistance, complete the coupon below and mail.

STANPAT CO. Whitestone 57, N. Y., U. S. A.
Phone: FLushing 9-1693-1611

☐ Please quote on enclosed samples.
☐ Kindly send me STANPAT literature and samples. Dept. 117

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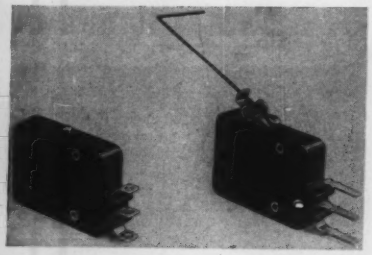
Address_____

Circle 498 on Page 19



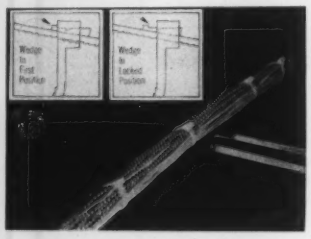
molded in place for maximum rigidity and resistance to movement. Haydon Switch Inc., Waterbury 20, Conn. B

Circle 643 on Page 19

Nylon Band Clamp

gives positive holding action

Wedge Lock band clamp employs a design that combines advantages of ratchet teeth and wedge to prevent slipping. Ratchet teeth on band engage with matching teeth inside clamp loop. Small, two-position, floating wedge is notched and can be engaged with a rib on inside of loop to provide permanent lock. Clamp is made entirely of nonconducting, noncorrosive, natural-color nylon. One size accom-



modates cable or wire diameters from ⅛ to 1¾ in. Weckesser Co., Dept. MD-1, 5701 Northwest Highway, Chicago 46, Ill. J

Circle 644 on Page 19

Epoxy Laminate

is low-cost, paper-base type

Paper-base epoxy-resin laminated plastic combines superior performance characteristics of glass epoxy laminates with fabrication ease of paper phenolic laminates. Designated Grade XY-1, it is furnished in 37 x 49-in. sheets from 1/32 to ¼ in. thick. It is also available in copper-clad form, Grade XY-1 Cu-Clad, for printed circuits. Copper-

(Advertisement)

No. 3 of a series

Eastman 910 Adhesive solves another production bottleneck

Recordak Corporation, New York City, offers microfilming equipment that photographs and endorses bank checks in one operation.

Rubber endorsing plates, rather than steel, were preferred yet could not be used because of the difficulty of securing the flexible rubber plate to the steel back, permanently and quickly.

The problem was solved with Eastman 910 Adhesive.

Coated lightly with adhesive, the plates are held in alignment in a simple jig. In a matter of minutes, the bond is formed...and the unit is ready for delivery and installation. *Field tests show the bond lasts for the life of the rubber printing plate.*

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-ounce) send five dollars to Armstrong Cork Company, Industrial Adhesives Division, 9107 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Division, Dept. M-7, Kingsport, Tenn.

Circle 499 on Page 19

Now!

Total Motor Burnout Protection*...

NO OTHER PROTECTOR PROVIDES 6-WAY COMPLETE PROTECTION

Most conventional protectors used today may protect motors against up to four overheat conditions. KLIXON Type T Protectors safeguard motors from all six conditions:

1. Running overload with or without high ambient or ventilation blocked.
2. Locked rotor normal voltage such as caused by mechanical failure of driven load.
3. Locked rotor caused by low voltage where decreased torque is insufficient to start load.
4. Locked rotor with main winding only in circuit resulting from open circuit start switch or open circuit in reversing switch.
5. Locked rotor with start winding only in circuit, such as that resulting from an open main winding circuit or open circuit in reversing switch.
6. Running with both start and main windings in the circuit resulting from start switch failure in closed position or low voltage which prevents reaching switchover speed.

Only New KLIXON Type T Protectors Completely Safeguard Your Motors

With KLIXON Type T Protectors in induction motors you are assured of *complete protection against all possible conditions that cause motor overheating and burnouts.* Here is how you benefit by using KLIXON-protected motors . . . motors operate at safe maximum output without premature failure . . . motor repairs, replacements and service are reduced . . . and most important, customer satisfaction and good will are retained. *Be 100% safe* . . . protect your motor-driven equipment completely against motor burnouts . . . specify on your purchase orders — "These motors to have KLIXON Type T Protectors."

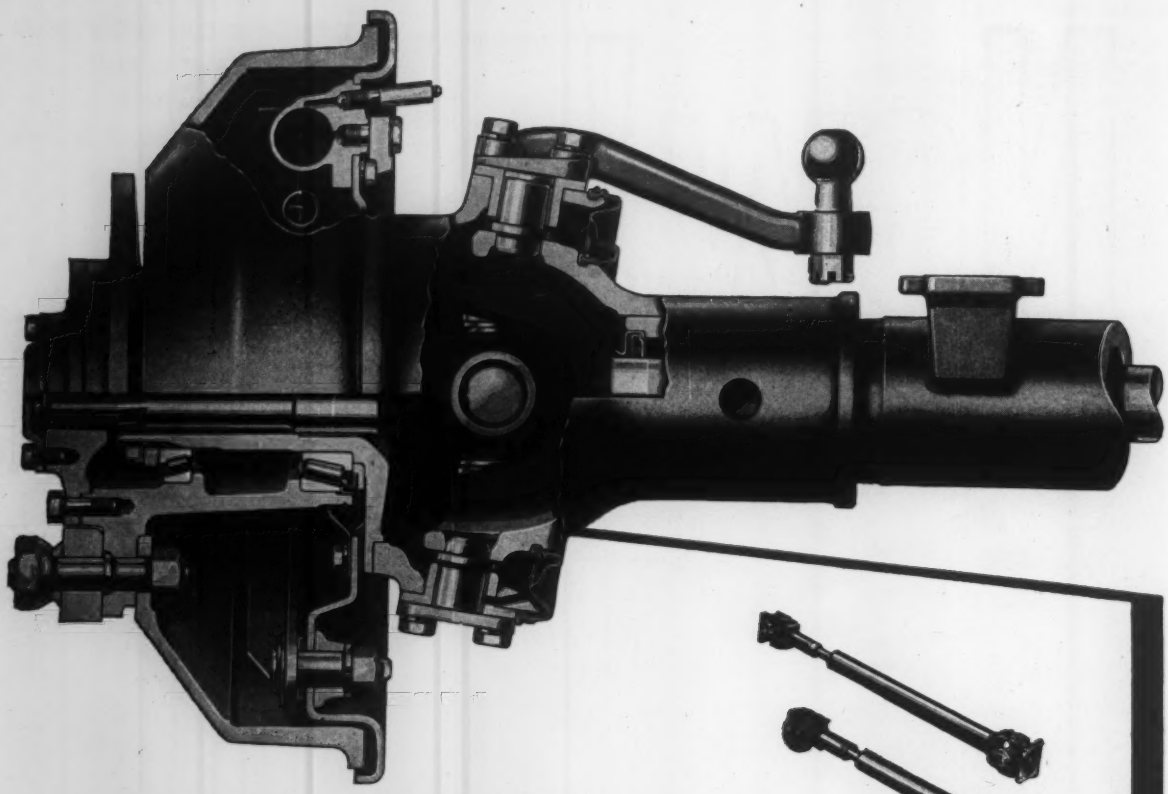
Over 150,000,000 motors are protected against overheating and burning out with KLIXON PROTECTORS.

METALS & CONTROLS

3207 FOREST STREET, ATTLEBORO, MASS., U.S.A.
A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

Spencer Products: Klixon® Inherent Overheat Motor Protectors
Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

Circle 500 on Page 19



For a better front-driving axle, get this Timken-Detroit FDS-750

equipped with

BLOOD BROTHERS Universal Joints

Here's another example of Blood Brothers' engineering cooperation . . . to produce ever-better truck components.

When this major axle source wanted an improved front-driving unit for a truck-building customer, their engineers and ours got together. The result shown above now provides users of famous brand trucks with *substantially increased capacity* on their front-driving axles.

Greater strength, better performance and lower costs may result for your products too—through a cooperative effort with Blood Brothers.

Just write or call—we'll arrange to meet at your convenience.

For a quick review of our products, request Bulletin 557.

STANDARD PROPELLER SHAFT ASSEMBLIES

SINGLE AND DOUBLE JOINTS FOR POWER TAKE-OFF USE

CLOSE-COUPLED JOINTS AND ASSEMBLIES

ROCKWELL-STANDARD CORPORATION

Blood Brothers Universal Joints

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

Circle 501 on Page 19

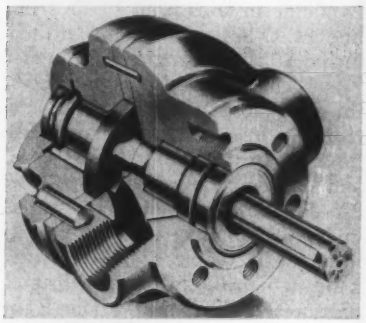
clad grade is expected to find wide use in computer applications where a high degree of reliability is required and reasonably low cost is desirable in the printed circuitry. Material has excellent bond strength and resistance to solder blistering, and is self-extinguishing. **Taylor Fibre Co.**, Norristown, Pa. E

Circle 645 on Page 19

Single and Double Pumps

for use with fire-resistant fluids

Series 800 Gerotor pumps are available from stock in 3, 5, 8, and 12-gpm sizes in QDH-830 single pumps, in 20, 30, and 40-gpm sizes in OG-860 single pumps, and in any combination of 3, 5, 8, or 12-gpm sizes in QGH-H-830 double



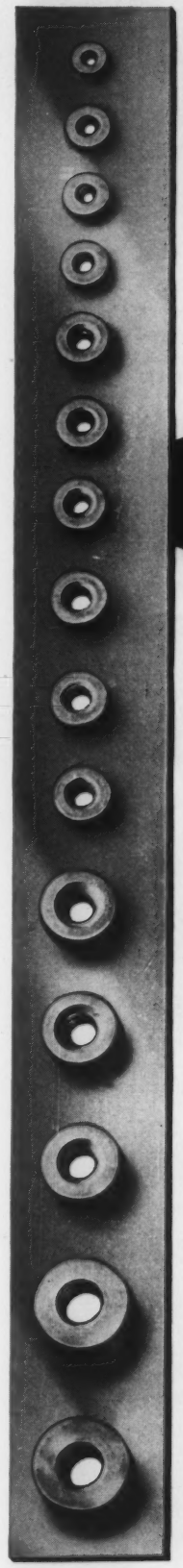
pumps. They are dimensionally interchangeable with regular Gerotor oil-hydraulic units of comparable capacities and also with other oil-hydraulic units. Pumps are for use with fire-resistant fluids in applications where fire hazards make use of hydraulic oils dangerous. **Double A Products Co., Hydraulics Div., Brown & Sharpe Mfg. Co.**, Manchester, Mich. H

Circle 646 on Page 19

Instrument Collars

have bores of 0.187, 0.25, 0.312 in.

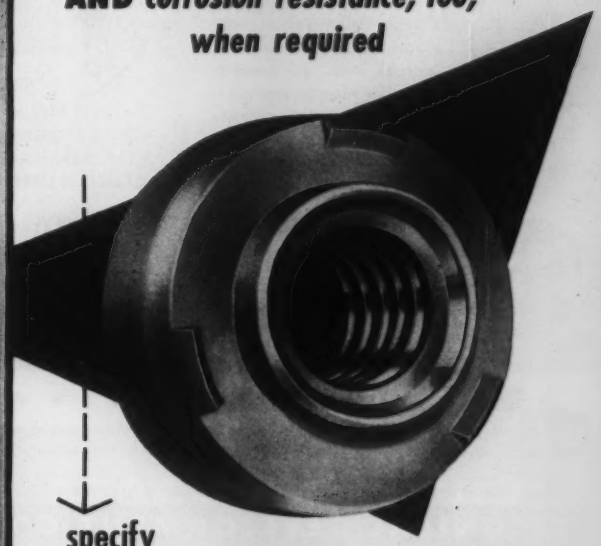
Stainless-steel instrument collars incorporate an integral shoulder 0.01 in. high and 1/16 in. larger in diam than bore. Shoulder eliminates need for spacers or extended inner-race bearing to insure clearance of outer bearing race. Two flat-end stainless socket setscrews mounted 90 deg apart enable firm grip without dan-



FASTER ASSEMBLY . . .

LOWER EQUIPMENT *and* LABOR COSTS . . .

AND *corrosion resistance, too, when required*



specify

PEM WELD FASTENERS

of steel or STAINLESS steel

PEM Weld Fasteners are designed for Production.

SHANK locates and protects threads against weld splatter . . . eliminates retapping.

ENGINEERED PROJECTIONS prevent burnouts in thin sheets.

SIMPLE ELECTRODES . . . no pilots required.

ROUND COMPACT SHAPE . . . no indexing in assembly . . . fit on narrow flanges.

WRITE for Bulletin WN-1158 and sample for trial.

Penn Engineering & Manufacturing Corp.
Doylestown, Pennsylvania

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Milwaukee—Bluemound 8-6118
Kansas City, Mo.—Grand 1-6314
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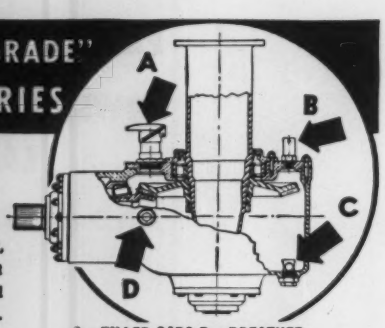
Circle 502 on Page 19

TEDECO "AVIATION GRADE"
GEAR CASE ACCESSORIES

SELF CLOSING MAGNETIC
DRAIN PLUGS

Permit convenient, direct, visual inspection without loss of fluid, no special tools, no electric gadgets. Automatic valve closes when magnetic plug is removed. Matching drain lines available.

THREADED OR BAYONET



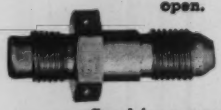
A—FILLER CAPS B—BREATHER VENTS C—DRAIN PLUGS D—OIL SIGHT GLASSES—ALSO LUBRICATION JETS, DRAIN LINES, ETC.

GEAR CASE
FILLER CAPS

Precision made of pressure die cast aluminum alloy. Short or long neck models. Snap closed, stay closed. Snap open, stay open.

LIQUID LEVEL
SIGHT PLUGS

Reflector assures visibility even in dark areas. Shows median level in agitated fluids. Easily installed in tapped holes.



BREATHER VENTS

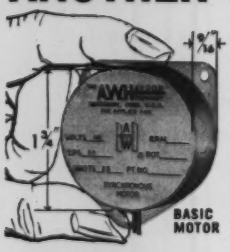
Designed with internal baffles against oil spillage and with effective metal filters. Conform to aircraft specifications.

Send for our complete catalog with working drawings of all sizes.

TECHNICAL DEVELOPMENT COMPANY
305 SOUTH CHESTER PIKE, GLENOLDEN, PA.

Circle 503 on Page 19

ANOTHER FIRST...



THE ONLY *Electro-Reliable*
A.C. TIMING MOTOR

Thinner... Quieter...
More Reliable... More Versatile

FINGER-THIN...
Only 9/16 Inches Short... Only 1¾ Inches in Diameter... very compact... reduces the size of your equipment.

WHISPER-QUIET...
Strictly an electrical motor... practically noiseless... no rattling of gears or ratchets.

HIGH TORQUE...
¼ oz. inch at the rotor with an instantaneous start and stop... requires only 2½ watts... can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY...
Longer life... no one-way gears or ratchets to fail... provides millions of operations without any trouble.

SPECIFICATIONS

Standard Voltage Ratings: 6, 12, 24, 115, 230 Volts
Frequency: 60 CPS Standard
25, 50 CPS Available
Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: ¼ oz-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: ⅞ inch

WITH INTEGRAL GEAR TRAIN

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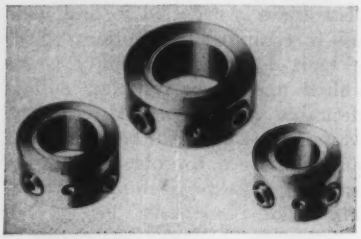
Send for Special Illustrated Bulletin AWH MO-806

The A.W. HAYDON Company
249 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

Circle 504 on Page 19



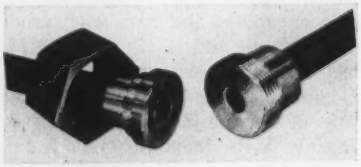
ger of burring shaft. Collars are provided with bores of 0.187, 0.25, and 0.312 in. They can also be used in place of bulkier, conventional split clamps to hold split-hub gears. **Gap Instrument Corp.**, 116 E. Merrick Rd., Freeport, L. I., N. Y. D

Circle 647 on Page 19

Valves and Fittings

O-ring types eliminate leaks at pressures to 5000 psi

Available in sizes from ¼ to 2 in., line of O-Seal valves and fittings includes globe, angle, and relief valves, check valves, nuts, tailpieces, threaded pieces, adapters, plugs, and reducing inserts. All are designed for pressures of 5000 psi or more, and for temperatures from −20 to 275 F. Positive sealing is assured under all conditions by an O-ring inserted in tailpiece. Even when hand-tightened, fittings withstand pressures to 5000 psi without leakage. High torquing of nuts is not required. Easily installed or removed, O-ring units permit rapid



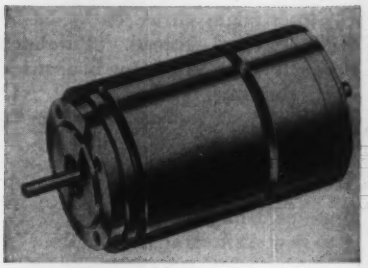
replacement or relocation of any valve or portion of piping without springing or cutting line. **Combination Pump Valve Co.**, Dept. 505, 851 Preston St., Philadelphia 4, Pa. E

Circle 648 on Page 19

Damped Servo Motors

have maximum operating temperature of 200 C

Line of 115-v, 400-cycle inertia and velocity-damped servo motors is available in sizes 11, 15, and 18. Size 11 unit characteristics include:



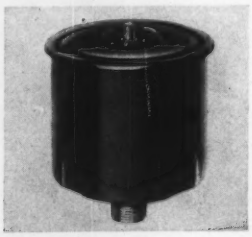
0.63 oz-in. torque at stall; 1.3 gm-cm² rotor inertia; 34,200 rad/sec² acceleration at stall. Size 15 characteristics include 1.5 oz-in. torque at stall, 2 gm-cm² rotor inertia, and 53,000 rad/sec² acceleration at stall. Characteristics of Size 18 include 2.35 oz-in. torque at stall, 4.5 gm-cm² rotor inertia, and 37,000 rad/sec² acceleration at stall. All models have passivated stainless-steel housings, are corrosion resistant, and have high-temperature laminations and encapsulated windings. Maximum unit operating temperature is 200 C for all models. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif. L

Circle 649 on Page 19

Small Air Filters

dry-type units have many applications

Dry-type air filters are for use on hydraulic breathers and all types of small air-cooled engines and air compressors. Two models with replaceable paper elements, designated AF-300 series, are adaptable for a wide variety of applications. Measuring approximately 3 x 4¾ in., filter accommodates flows up to 15 cu ft of air per minute and removes contaminants as small as 10 mu from air stream. Fibrous wrap around ID of paper element prevents oil blowback from saturating filter medium, increasing life of filtering element. Units have either



Circle 505 on Page 19→

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS

of smooth, tough DuPont NYLON

Low Cost FLANGED Nyliner | Low Cost SLEEVE Nyliner | Low Cost DOUBLE-FLANGE Nyliner

BETTER BEARINGS THAT...

• COST LESS to BUY*
• COST LESS to INSTALL
& ELIMINATE LUBRICATION

Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
- NO FRICTION OXIDATION
- DAMP VIBRATION
- OPERATE IN LIQUIDS
- NON-CONTAMINATING
- INSTANTLY REPLACEABLE
- RESIST ABRASION
- MINIMUM SPACE
- SILENT OPERATION
- LIGHTEST WEIGHT
- REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

**In production quantities at new, REDUCED PRICES.*

THOMSON INDUSTRIES, Inc.

DEPT. 4, MANHASSET, NEW YORK

Also— —Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting

Takes performance guesswork out of power transmission design

With these performance-proved units, you can save time and money in designing and building clutches and brakes exactly tailored to the requirements of your application. At the same time, you can be sure that they will equal the performance and smooth operation of proved MAXITORQ clutches and brakes. DISC-PACS are simply the "heart" of a clutch or brake . . . the discs, separator springs, and locking plate . . . supplied as a complete self-contained unit for the convenience of design engineers and equipment builders.

Produced in a full range of sizes and capacities from ¼ h.p. to 15 h.p. Bulletins available on other MAXITORQ products: Floating Disc clutches and brakes, Electric clutches, Overload Release clutches, low-cost Single Disc clutches, and clutch or brake friction discs. Write Dept. MD-7.

THE CARLYLE JOHNSON MACHINE CO.
Manchester, Connecticut

ECJ59

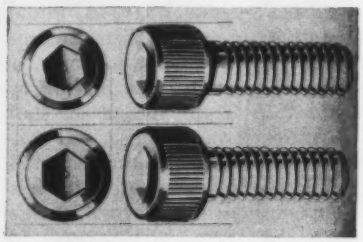
1½-in. straight throat or ½ in.-14 NPT external thread. **Purolator Products Inc.**, 970 New Brunswick Ave., Rahway, N. J. D

Circle 650 on Page 19

Socket Cap Screws

are cold forged to new ASA standards

Cold-forged, socket-head cap screws have a larger head and bigger hex wrench pad than previous standard



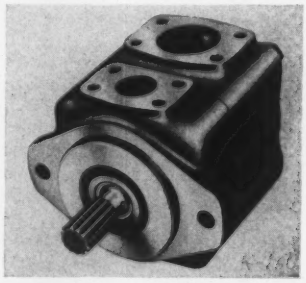
types. Manufactured to new ASA standards, screws have greater tightening torques without rupture of head, higher loads without indenting material, and long life. **Set Screw & Mfg. Co.**, Bartlett, Ill. I

Circle 651 on Page 19

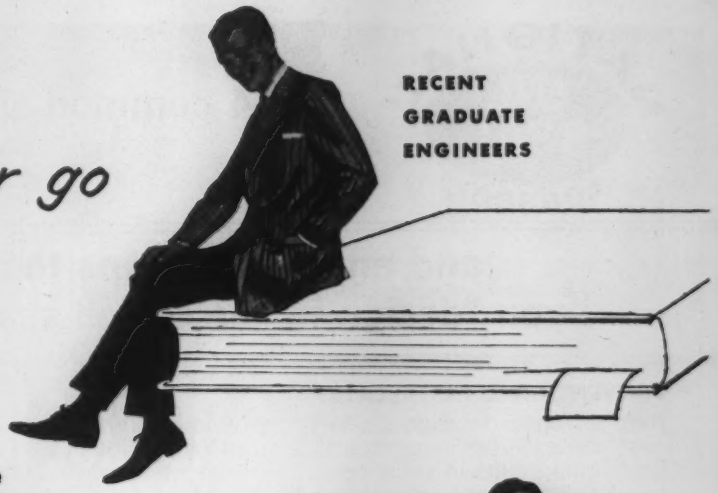
Vane Pump

for speeds to 2000 rpm and pressures to 2000 psi

Three models of Series 45 vane pump deliver 52, 63, and 75 gpm at 2000 rpm and 2000 psi. Delivery at 1200 rpm, 100 psi, is 34, 41, and 48 gpm respectively. Pump housing accommodates any of three pumping cartridges, which permits easy change of delivery rate. All wearing parts of pump are incorporated in replaceable cartridge. Pump overhaul, accomplished by replacing cartridge, can be done quickly without removing pump from mounting. Other features include high over-all efficiency, long



How far can an engineer go at AC?



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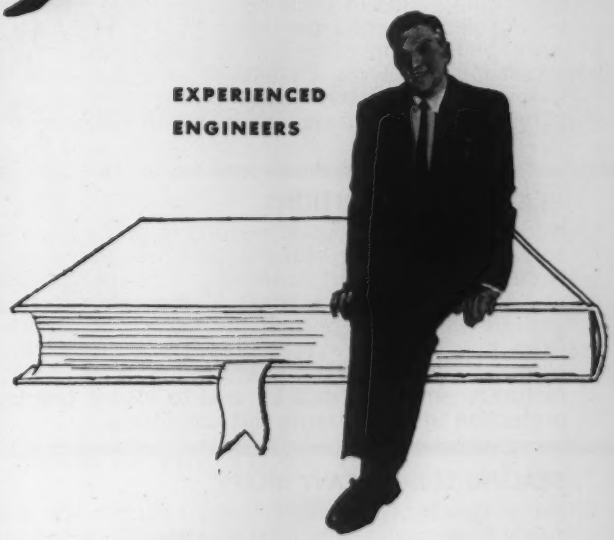
Three levels of special advanced training that can help you prepare for promotion and enhance your professional status. That's what you'll find when you go to work in AC's instrumentation business.

Program A—for recent graduate engineers—gives you a solid foundation in the theory and application of inertial guidance systems and servomechanisms.

Program B—for experienced engineers—consists of upgrading studies in inertial guidance, servomechanisms, environmental problems, engineering math and physics, plus advanced state-of-the-art courses.

Program C—for all engineering supervisors—involves management training developed by a team of AC executives and University of Chicago industrial relations experts.

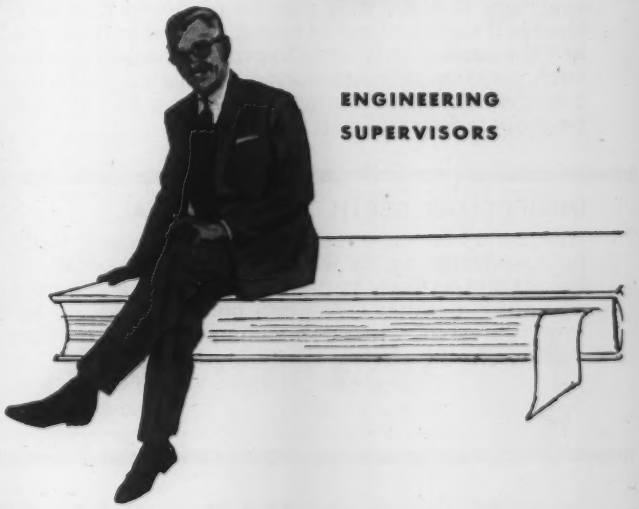
Comparison will prove these are the finest "in house" programs available anywhere. And they are educational "extras," for AC offers them in addition to their educational assistance programs for men who wish to study for advanced degrees in nearby universities.



You may be eligible for training . . .

if you are a graduate engineer in the electronics, electrical or mechanical fields, or if you have an advanced degree in mathematics or physics. You'll study while you work on the renowned AChiever inertial guidance system or a wide variety of other electromechanical, optical and infra-red devices.

For more information, write the Director of Scientific and Professional Employment: Mr. Robert Allen, Oak Creek Plant, Dept. C, Box 746, South Milwaukee, Wisconsin.



AC SPARK PLUG ❀ THE ELECTRONICS DIVISION OF GENERAL MOTORS

INERTIAL GUIDANCE SYSTEMS • AFTERBURNER FUEL CONTROLS • BOMBING NAVIGATIONAL COMPUTERS • GUN-BOMB-ROCKET SIGHTS • GYRO-ACCELEROMETERS • GYROSCOPES SPEED SENSITIVE SWITCHES • SPEED SENSORS • TORQUEMETERS • VIBACALL • SKYPHONE

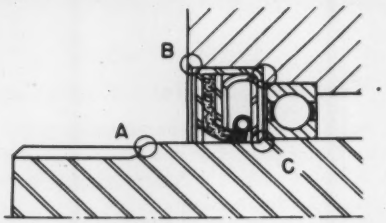
NATIONAL® OIL SEAL LOGBOOK

4 common shaft sealing conditions

. . . and engineering tips that can help you "design-in" better oil seal performance

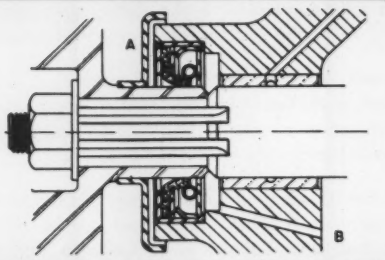
CONVENTIONAL INSTALLATION

Here a standard-design single lip seal retains lubricant and excludes normal dirt, dust and moisture. Sealing lip points in since seal's principal job is retaining oil or grease around bearing. Note that shaft is stepped and chamfered at "A" to prevent damage to sealing lip during installation. At "B", bore is chamfered to facilitate seal entry. At "C", counterboring insures accurate positioning of the seal.



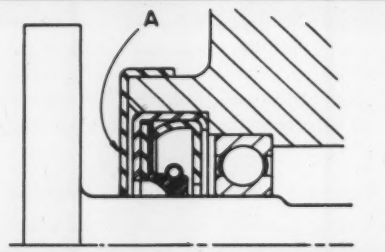
HEAVY DIRT CONDITIONS

Here is a commonly used method of protecting the seal and increasing seal life on applications subjected to extreme dirt conditions. The guard baffle at "A" is welded or swaged to the wheel hub to exclude the major portion of dirt and dust. The drain hole at "B" relieves pressure at the sealing point. In addition to the guard baffle, many manufacturers employ a dual-lip seal to insure bearing protection under extreme dirt conditions.



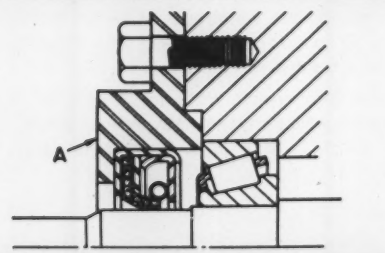
SEALING LONG, HEAVY SHAFT

Many cases of so-called "seal failure" are due solely to poor installation techniques. While today's seals are rugged, they can be rendered non-serviceable if distorted out of round, cocked in the bore, or if the sealing lip is torn. To protect the seal against such physical damage during installation involving a long shaft, a seal protector as shown at "A" may be mounted on the hub O.D.

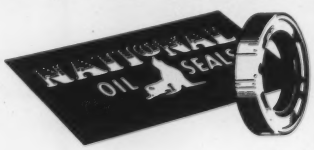


INSUFFICIENT DEPTH TO MOUNT SEAL

Where the housing does not provide sufficient depth for counterboring, or where seal installation would be difficult or likely to damage the seal, a separate mounting member ("A") can be employed. As before, the shaft should be chamfered to prevent damage to the sealing lip during installation.



NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California
Van Wert, Ohio



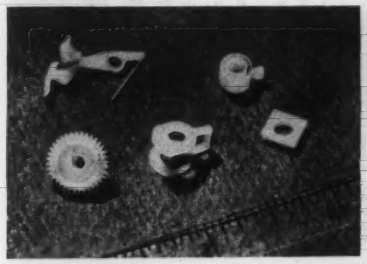
8207

service life, and four-position cover. **Vickers Inc., Div., Sperry-Rand Corp.**, Detroit 32, Mich. H

Circle 652 on Page 19

Small Plastic Parts

are injection molded of Delrin acetal resin



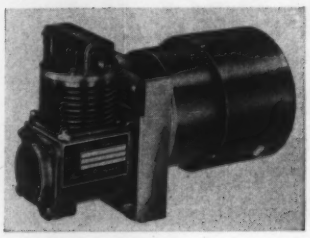
Tiny plastic parts of Delrin acetal resin are available for use in many applications. Parts shown include a coupling, pawl, bobbin jacket, cam gear, and lock nut. Material has excellent creep resistance, high strength and stiffness, low permeability, and resistance to solvents and corrosion. **Gries Reproducer Corp.**, 125 Beechwood Ave., New Rochelle, N. Y. D

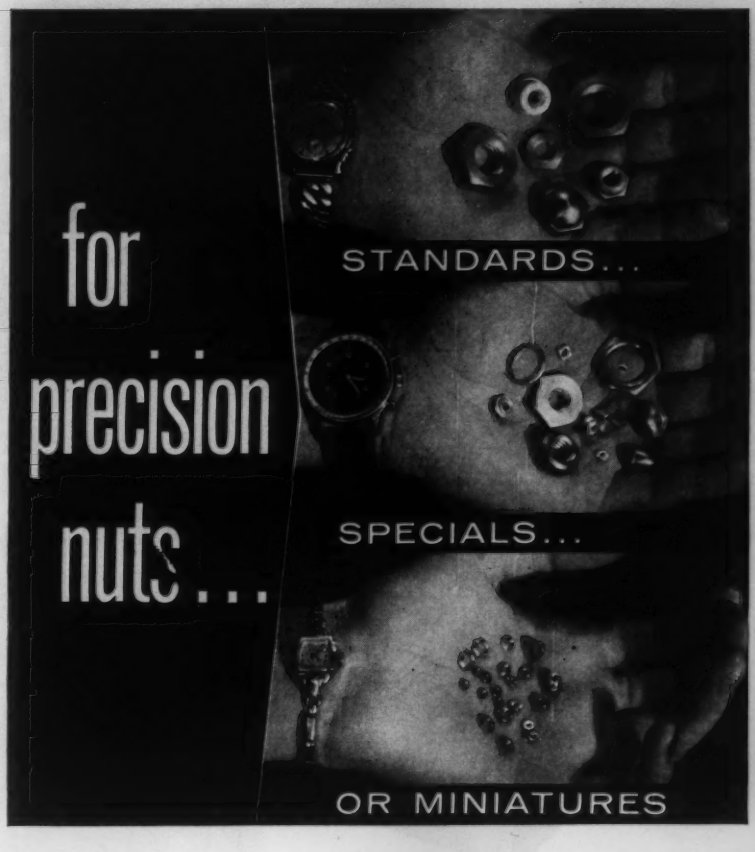
Circle 653 on Page 19

Air Pump

produces oilfree compressed air

Single-piston air pump, Model 04-301, is a precision, multiple-purpose unit designed for the production of oilfree compressed air. Use of Graphitar and Teflon piston rings has eliminated need for cylinder lubrication, and prelubrication of bearings and other moving parts assures troublefree operation. Pump is a compact and lightweight unit for continuous or intermittent operation with practically no maintenance. Capacity of pump at 50 psig is 127 cu in. per min. Pump is available with a 1/8-hp, 400-cycle





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As the leading producer of precision *turned* nuts, Fischer can meet or exceed every requirement for quality, delivery and price. Fischer's high-speed automatic machines generate extremely accurate nuts with mass-production savings. To assure dependable "on schedule" deliveries, Fischer uses an I.B.M. system to co-ordinate all orders, production scheduling, inventory stocks and shipping dates.

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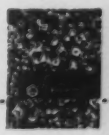


Please send your 20-page CATALOG FS-1000 on brass and aluminum nuts.

FISCHER SPECIAL MFG. CO.
451 MORGAN ST., CINCINNATI 6, OHIO

Name_____ Title_____

Company_____

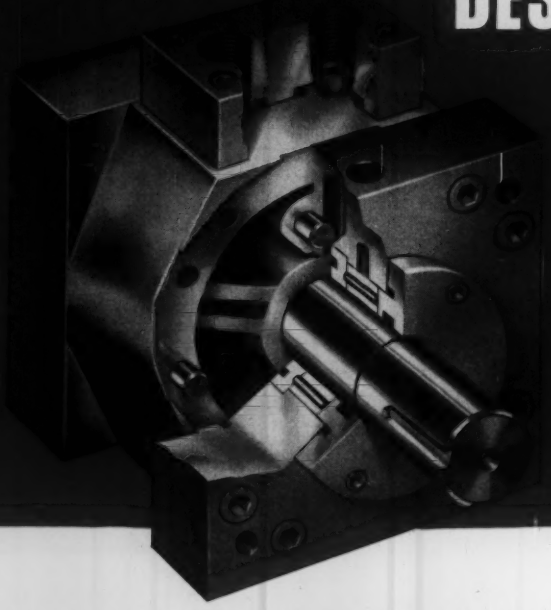
Street_____

City_____ Zone____ State_____

8295-FS

Circle 508 on Page 19

From 26 STANDARD MODELS— 312 MODIFIED STYLES FOR DESIGN FLEXIBILITY!



RŌTAC

Reciprocating Rotary Torque Actuators

Rōtac units illustrated are standard Model HN (at right), Model RN (top left); bottom, special Rōtac actuator delivers 1,400,000 in./lbs. torque at 1,000 psi.

Rōtac gives greater design flexibility wherever you need *movement, instant torque, and a compact power package!* From 26 catalogued models you can draw on 312 "standard modifications"—to meet your special needs in size, torque, load, travel, temperature or operating pressure. Engineering service is available for unusual applications.

BRIEF RŌTAC FACTS—Torque ratings from 100 to over 200,000 inch-pounds. Single or double-end shaft, key or spline. Uses air, oil or fire-resistant fluids. Mounts at any angle, singly or in manifold installations, with shaft or body rotating. Precise control of travel arc through 280 degrees. Construction to J.I.C. standards. Few internal moving parts and total absence of external moving parts insures long life, trouble-free performance.

59-R-46

HOW CAN YOU USE RŌTAC?

Rōtac Actuators simplify design, production and maintenance in such industries as foundry and heavy machinery, precision machine tools, automated production equipment, marine, mobile and materials handling, paper, printing and plating. Here are some typical uses:

Continuous rotation • Lift—lower • Oscillate • Index—position • Screw clamp • Toggle—cam pushing • Load-unload • Transfer • Press • Intermittent feed • Turnover • Constant tension • Conveyor turn or stop

FREE DESIGN DATA BOOK—20 pages on how Rōtac works, torque ratings, control, dimensions, installation, typical applications and special uses. See your Rōtac Representative or write direct.

EX-CELL-O FOR PRECISION XLO

EX-CELL-O CORPORATION

GREENVILLE PLANT, 945 E. SATER ST.
GREENVILLE, OHIO

EX-CELL-O PRECISION PRODUCTS INCLUDE: MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • TORQUE ACTUATORS • THREAD AND GROOVE GAGES • GRANITE SURFACE PLATES • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • DAIRY EQUIPMENT

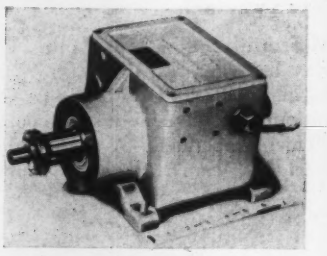
motor, either single phase at 115 v or three phase at 200 v. **Applied Dynamics Corp.**, 32 N. Main St., Natick, Mass. B

Circle 654 on Page 19

Drive Unit

provides intermittent motion from constant rotary power

IDU drive unit features highly flexible manual, mechanical, or electrical control, permitting demand-type operations in fixed or variable cycles. All components are totally enclosed in an oil-bath housing.



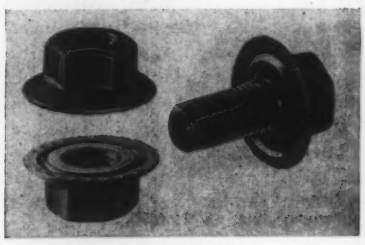
Unit can be installed easily, needing only electrical connection. **Hilliard Corp.**, West Fourth Street, Elmira, N. Y. N

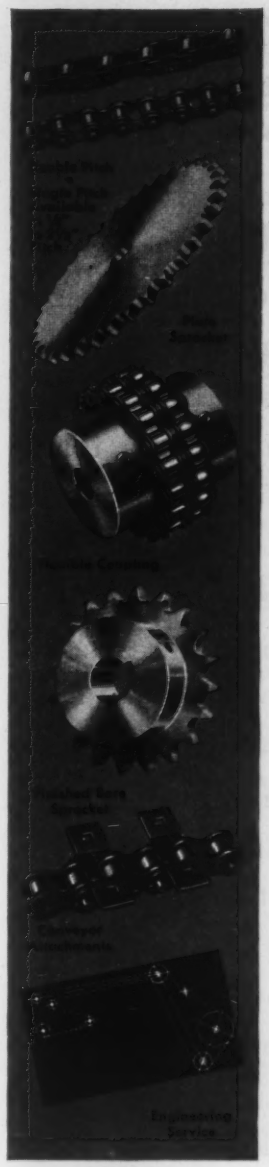
Circle 655 on Page 19

Locking Fasteners

provide excellent locking performance

Flanged high-tension locking fasteners, known as Tensilock locking screws and nuts, provide superior locking performance and eliminate need for washers in assembly of metal products. One-piece fasteners lock with both ratchetlike teeth and high thread tension. Carburized teeth on flanges of screw and nut are angled on advancing side to allow low-friction tightening, but are vertical on back side to prevent loosening. Units require nearly 150 per cent of application torque to loosen. High tension-to-torque ra-





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Circle 510 on Page 19

How to LOCK-UNLOCK-RELOCK the same screw in Steel without Lock Wiring or Lock Nuts

The ***Heli-Coil***® Screw-Lock Insert* is the only insert made of wire which has an exclusive resilient internal locking feature that permits repeated assembly and disassembly of the same screw This patented insert insures minimum screw wear and maximum locking torque value—it meets military specs for locking torque and vibration through 550°.

Made of stainless steel wire, the Screw-Lock Insert protects tapped threads permanently and is not affected by acids, solvents or high temperatures You can eliminate lock nuts, lock wiring and other clumsy external locking devices The locking coil will never relax its grip even in tough metals such as meehanite, stellite, titanium, etc. The insert can be used in blind or through-holes and its frictionless stainless steel finish will not gall or seize—even under the most adverse conditions Find out about ***Heli-Coil*** Screw-Lock Inserts and get your free copy of the new data guide to drilling and tapping in *steel* Mail the coupon today.

*Patented

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 507 Shelter Rock Lane, Danbury, Connecticut
Please send my free copy of the new *Heli-Coil* DATA GUIDE TO DRILLING AND TAPPING IN STEEL, and information on *Heli-Coil* Screw-Lock Inserts.

NAME _____ TITLE _____
FIRM _____
ADDRESS _____
CITY _____ ZONE ____ STATE _____ 1810

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

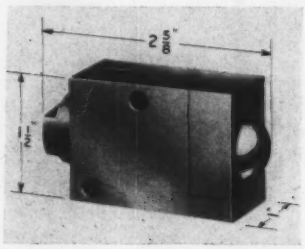
tio permits full preloading of fasteners to prevent slippage of fastened members. Prelubricated screws and nuts have tensile strength of 125,000 psi. Fasteners are available in sizes from No. 6 to 3/8 in. Screws are available in any length from twice diameter up and in a wide range of sizes and styles, except flat head. **Russell, Burdsall & Ward Bolt & Nut Co.**, 103 Midland Ave., Port Chester, N. Y. D

Circle 656 on Page 19

Ball-Cam Valve

is inexpensive, two-way unit

Measuring 2 5/8 x 1 1/2 x 1 in., two-way ball-cam valve has full 1/8 and 1/4-in. orifices (0-200 psi). Corrosionproof valve has a single poppet element operated by a stainless-steel ball cam. All other exposed



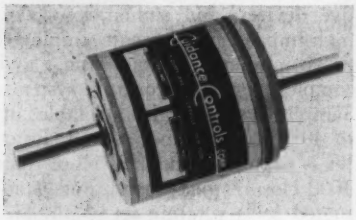
parts are anodized aluminum. Unit can be mounted in any position by means of two mounting holes. **Airmatic Valve Inc.**, 7317 Associate Ave., Cleveland 9, Ohio. G

Circle 657 on Page 19

Magnetic Clutch

provides high output torque

Type C-18 magnetic clutch offers as much as 400 per cent increase in output torque over clutches of comparable size. For friction-face models, minimum output torque is 80 oz-in. at 24 to 28 v dc. Breakaway torque is 0.15 oz-in. energized and 0.05 oz-in. de-energized. Maximum weight is 13.5 oz. Clutch meets Mil-E-5272B environmental qualifications tests for vibration, fungus, shock, humidity, temperature, salt spray, sand, and dust. Specifications include zero backlash and zero to 0.0003 in. end play, maximum. With maximum recommended speed of 5000 rpm, engagement time is 4



millisec. Power consumption is 3.5 w. Special requirements can be met with respect to shafts, gears, temperature range, voltages, and torque. **Guidance Controls Corp.**, 110 Duffy Ave., Hicksville, L. I., N. Y. D

Circle 658 on Page 19

Gear Lubricant

has good load-carrying ability

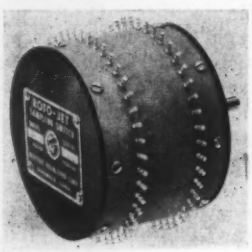
Heavy-duty gear lubricant, Type 223X, is available in SAE 90 and 140 grades. It provides satisfactory lubrication where gear cases are operating at excessive frictional temperatures, where there is unsatisfactory wear life, and where gears are loaded beyond recommendations. Lubricant has good load-carrying ability through entire range from lowest to highest sliding velocities, and it is most effective in reducing wear. It has viscosity index of 100, flash point of 390 F, fire point of 420 F. Specific weight is 7.4 lb per gal, and it has a pour point at 0 F. Lubricant contains a foam depressant, and is corrosion and oxidation inhibited. **Alpha-Molykote Corp.**, 65 Harvard Ave., Stamford, Conn. B

Circle 659 on Page 19

Sampling Switch

makes more than 3600 closures per sec

Noiseless, wiperless sequential sampling switch can be used with thermocouples, strain gages, light-sensi-



Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66v.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

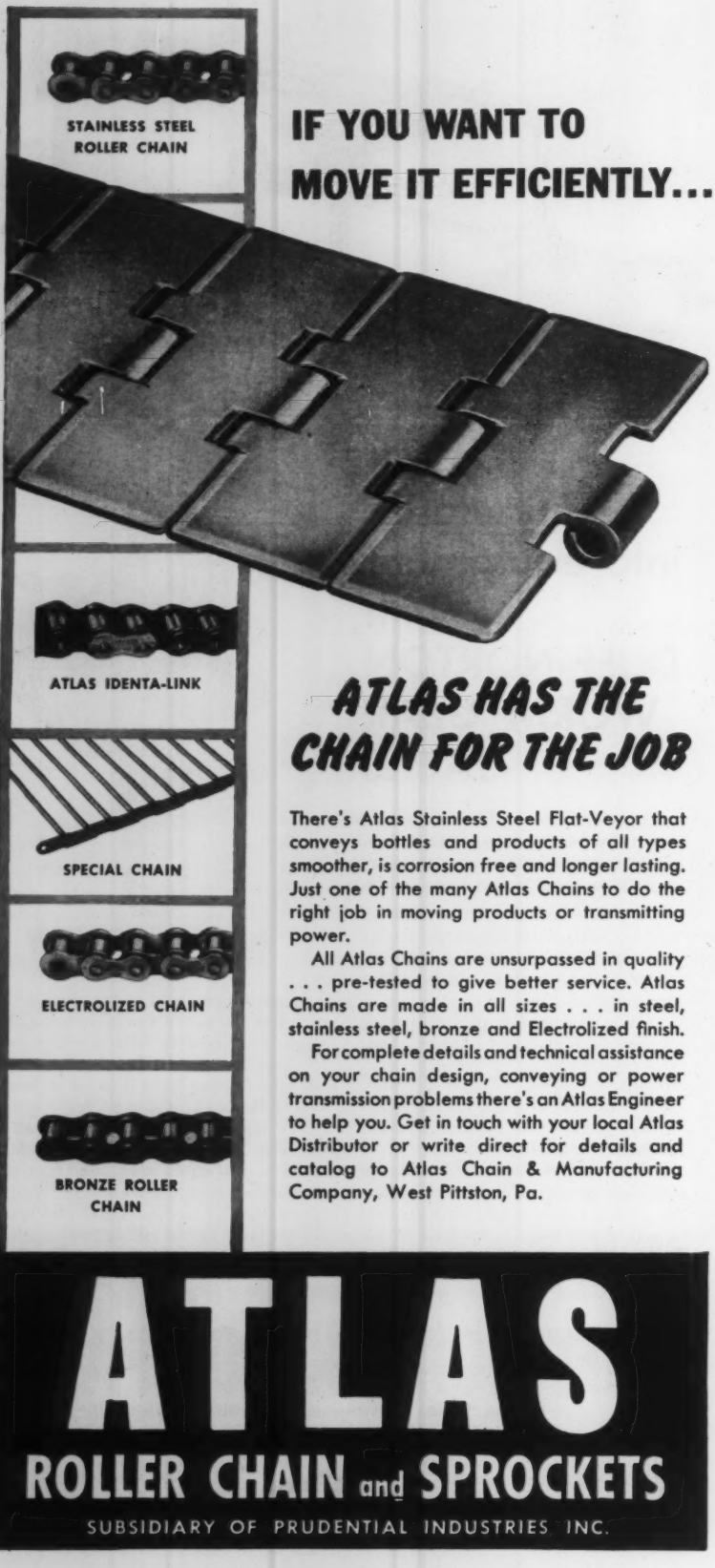
COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

Circle 512 on Page 19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IF YOU WANT TO MOVE IT EFFICIENTLY...
ATLAS IDENTA-LINK
ATLAS HAS THE CHAIN FOR THE JOB
SPECIAL CHAIN
There's Atlas Stainless Steel Flat-Veyor that conveys bottles and products of all types smoother, is corrosion free and longer lasting. Just one of the many Atlas Chains to do the right job in moving products or transmitting power.
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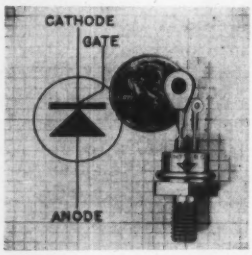
For complete details and technical assistance on your chain design, conveying or power transmission problems there's an Atlas Engineer to help you. Get in touch with your local Atlas Distributor or write direct for details and catalog to Atlas Chain & Manufacturing Company, West Pittston, Pa.
ELECTROLIZED CHAIN
BRONZE ROLLER CHAIN
ATLAS
ROLLER CHAIN and SPROCKETS
SUBSIDIARY OF PRUDENTIAL INDUSTRIES INC.

tive devices, and similar low-level, high-impedance elements employed in computers, telemetering, and complex process control systems. Sampling speeds are available up to 40 revolutions per second. Roto-Jet is capable of making more than 3600 closures per second, and is actuated by a rotating jet of air. Signals of 1, 2, and 3 mv can be transmitted completely free from noise without amplification or filtering of any kind. Up to 45 contact pairs, made of palladium, platinum, gold, silver, and copper alloy, are constructed in modules and positioned inside a cylindrical enclosure. Contact is made and broken by rotating jet of air directed at high speed toward module pairs. Switch can be mounted in any position. **Electric Regulator Corp.**, Pearl Street, Norwalk, Conn. B

Circle 660 on Page 19

Silicon Controlled Rectifier

for uses requiring blocking voltages to 200 v



Three-junction silicon controlled rectifier combines some characteristics of rectifier and power transistor. It is available for applications requiring blocking voltages to 200 v and load currents to 10 amp. Unit is capable of switching rapidly to a conducting state either when a signal is applied to third terminal or when critical forward breakover voltage is exceeded. After it has fired, controlled rectifier exhibits low forward voltage drop of a single-junction rectifier. Device provides very rapid firing and recovery times, operation to 100 C, and elimination of filament, filament transformer, warmup delay, and standby power comsumption. Series X10RC 2 through X10RC 20 is rated for average currents to 10 amp and is available with peak inverse voltage ratings of 20, 30, 50, 70, 100, 150,

Circle 513 on Page 19

and 200 v. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

Circle 661 on Page 19

Speed Reducer

has cooling fins and powered cooling fan

P-series Hi-Line speed reducer is of right-angle, vertical style, employing a worm and gear reduction. It features cooling fins plus a powered cooling fan to provide up to 80 per cent greater load capacity than comparable nonventilated models. Reducer is available with low base, high base (shown), or with no base. Sizes range from 1.33 to 5.25 in. center distance with wide variety of standard reductions ranging from 1:1 to 60:1. Reducer features heavy-capacity antifriction bearings, short center distance between worm and gear, and improved heat-dissipation characteristics. **Ohio Gear Co.**, 1333 E. 179th St., Cleveland, Ohio. F

Circle 662 on Page 19

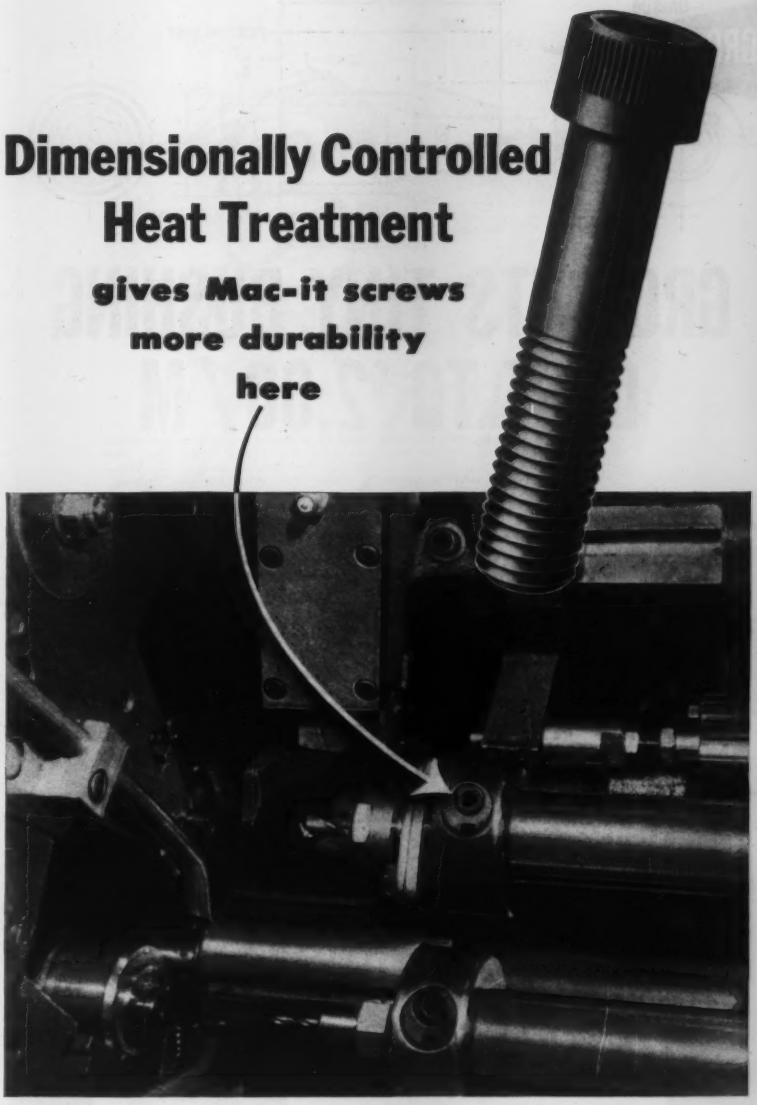
Swivel Connector

delivers hydraulic fluid at any angle

New 90-deg swivel connector for industrial use delivers hydraulic fluid at any angle under adequate pressure, eliminating hose failure due to extreme flexing. Connector absorbs part of the swing so that less hose allowance is needed for complete extension of moving part. Stiffer, longer - lasting, multiple-spiral wire hose can be employed because connector takes up part of flexing action. Low torque operation and freedom from friction is assured at pressures up to 5000 psi. Fluid pressure is absorbed equally by a double seal at each end of stem. Various combinations of

Dimensionally Controlled Heat Treatment

gives Mac-it screws more durability here



The heat treatment specifications for every Mac-it alloy steel screw are determined by its dimensions as well as its intended use.

At Mac-it, large and small diameters are not run through the heat treating processes indiscriminately. Instead, our metallurgists establish a heat treating cycle for each type and size. This assures that every screw has the proper combination of strength, toughness, ductility and resistance to vibration and shock.

Dimensionally controlled heat treatment is just one illustration of the care which is taken in every step in the manufacture of Mac-it screws. That's why Mac-its *hold tight in a tight place.*

Buy by name from your distributor—buy Mac-it

NEW SPECIFICATION SHEET listing new 1960 Series Socket Screw Industry Dimension Standards. Write for your *free* copy.

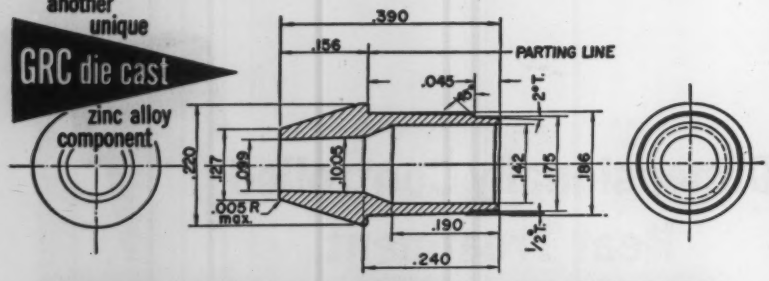
Mac-it Parts Co., Dept. 21, Lancaster, Pa.

Mac-it®

MAC-IT ALLOY STEEL SCREWS

Circle 514 on Page 19

another unique GRC die cast zinc alloy component



GRC CUTS TINY BUSHING COST TO $2.00/M

Die cast by GRC in zinc alloy in a single automatic operation, this former screw machine part for a ball point pen, now costs little more than $2.00 per thousand in lots of a million. Each bushing is uniform, clean and accurate—no cut-off marks, no burrs, no secondary trimming and no scrap loss. Typical of the production economies and wide design latitude which GRC's exclusive patented methods have made possible on parts "no bigger than your thumbnail." (Maximum size is 1¾" long, ½ oz.; no size too small).

Simple or complex, let GRC's unique techniques go to work for you . . . on tiny die cast *and plastic molded* parts made to order . . . on their wide variety of standard parts available in stock—die cast wing and round head thumb nuts and screws, cap nuts, molded nylon screws, gears and pinions—you'll be glad you did.

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Circle 515 on Page 19

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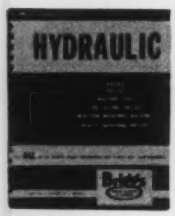
HERE is a big 8½" x 11", file size, 12 page, fully illustrated booklet. It's brimful of technical data and drawings that every designer and engineer will want to read or keep for ready reference. Write for your copy. No obligation.



Briggs

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YES! AT NO COST or obligation, send me the above booklet.

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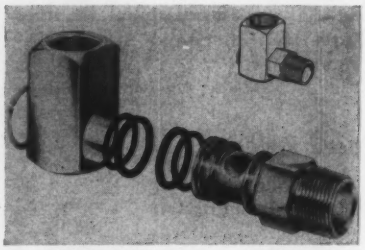
Company .....

Address .....

Circle 516 on Page 19



stems can be interchanged with any body style. Ends available include male pipe, hydraulic male, O-ring male, solid and swivel female, in sizes from ½ through 1½ in. **Eastman Mfg. Co.**, Manitowoc, Wis. K

Circle 663 on Page 19

Timing Belt Drive

makes possible speeds to over 16,000 fpm

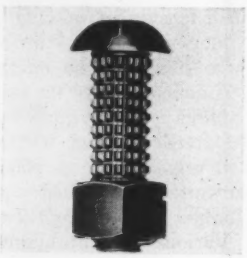
Highly versatile in application, load range, and speed range, Time-Tex timing belt drive is constructed with steel cable cords imbedded in neoprene fully molded with nylon-base fabric. Drive is suitable for a wide range of load applications, from subfractional to 600 hp with wide torque load range. Drive makes possible speeds to over 16,000 fpm. Small pulleys, short centers, narrow belts, and high capacities combine to reduce space requirements. Chatter, vibration, and friction are eliminated. Drives are available in 1/5, ⅜, ½, ⅞, and 1¼-in. pitches. **Allis-Chalmers Mfg. Co.**, Milwaukee 1, Wis. K

Circle 664 on Page 19

Structural Rib Bolt

meets ASTM A-325 specifications

High-tensile, structural bolt with interrupted ribs is heat-treated, high-carbon steel and meets ASTM A-325 specifications. It does not have to be torqued. Bolt eliminates



steel plates riding on bolt threads, and is easy to drive or pull through plates. It is for use wherever high-strength bolting is required in punched or drilled holes. **Automatic Nut Co.**, Willow Street, Lebanon, Pa. E

Circle 665 on Page 19

Miniature Relay

incorporates all-welded construction

Four - pole, double - throw micro-miniature relay is assembled by an inert arc-welding process which hermetically seals header to can. Use of the welded construction eliminates contact contamination due to solder flux. Weighing about 1 oz, relay is rated 2 amp at 26.5 v dc or 115 v ac. For application in a variety of equipment, relay is

suited for high-temperature installations. It is rated from 160 C continuous ambient down to −65 C. Relay can be mounted directly on printed-circuit board or on a chassis. Operate and release times are 6 and 4 millisec respectively, including bounce, and pickup power is 400 mw. Relay withstands vibration to 200 cps at 30 g and shock at 50 g for 11 millisec. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 666 on Page 19

Small Fan

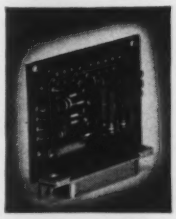
has diameter of only 1½ in.

New fan is designed for airborne applications where size and weight must be held to a minimum, where reliability is critical, and where high heat loads must be dissipated with cooling air. Aximax 1 is 1½ in. in diam by 1½ in. long, and weighs 4 oz. Constant 22,500 rpm design delivers 23 cfm free delivery or 19 cfm at 1-in. static pressure. Avail-

Now! A higher reliability factor in printed circuits

ALTORI

a new and distinctively different finish on TAYLOR copper-clad laminates that accepts all acid resists uniformly



Something new and distinctively different has been added to TAYLOR copper-clad laminates — a finish that accepts all types of acid resists uniformly. High fidelity in printed circuit reproduction is assured. Circuits can be of consistently higher quality and reliability, no matter how critical the design. For complete details about TAYLOR copper-clad laminates and samples, write TAYLOR FIBRE CO., Norristown 47, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

Circle 517 on Page 19

now! get this NEW

problem-solving money-saving

Setko Catalog 23 FREE

- **Includes new self-locking set screw selector chart.**
- **Latest styles of socket screws including: button heads, flat heads, shoulder screws, dowel pins.**
- **Complete information on cost-cutting Setko hopper feed method of inserting set screws.**

Lists all standard set screw and socket screw products . . . plus many special types designed for unusual conditions of vibration; close precision setting; resistance to tampering, etc. Describes many specific ways in which Setko Set and Socket Screw products cut costs, improve product quality.

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A new Free Setko service designed to help you *cut costs — speed up production — increase quality* . . . Setko Engineers have helped many Companies save thousands of dollars through planned re-analysis of their socket, slotted and slabbed set screws as well as socket cap screw needs. Write today for full information . . . Ask about "Operation Re-Analyze."

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SETKO

We Specialize in Solving Puzzling Set Screw Problems

Circle 518 on Page 19

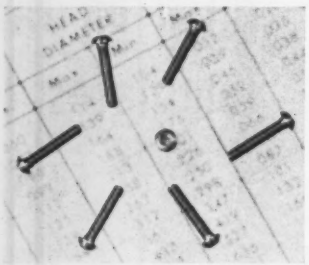
able motor designs include 115 or 200 v ac, 1 or 3 phase, 400 cps for either pressurized or nonpressurized applications and for sine or square wave. Electrical connection is made to a compact terminal block. Mounting is accomplished through provision of clamping rims at each end of barrel. Direction of air flow is reversed easily by turning fan over and remounting, using opposite rim. **Rotron Mfg. Co.**, Woodstock, N. Y. D

Circle 667 on Page 19

Socket Screws

miniature units resist shock and vibration

Miniature button-head socket screws in Dyna-Mite line are available with either standard hex or spline sockets in alloy or stainless steel. They are recommended for resist-



ance to shock and vibration. Screws are available in sizes No. 0 through No. 3. **Bristol Co.**, Waterbury 20, Conn. B

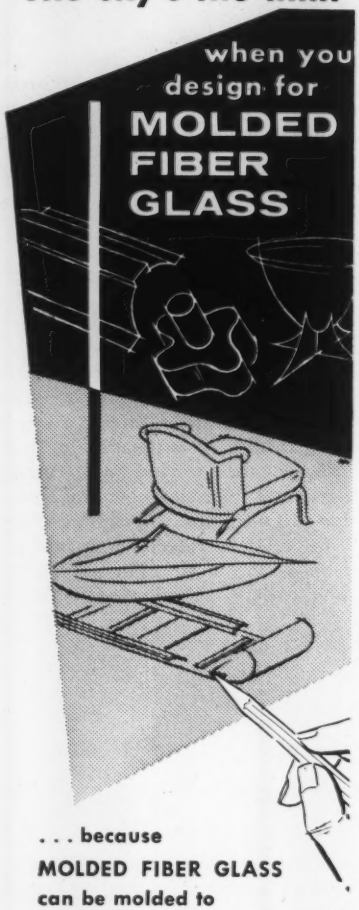
Circle 668 on Page 19

Wire-Wound Resistor

costs less than carbon unit

New 2-w wire-wound resistor is available in ±5, 10, and 20 per cent tolerances. It costs from 5 to 27 per cent less than carbon resistors, depending on quantity, toler-

The sky's the limit



. . . because MOLDED FIBER GLASS can be molded to almost any size or shape

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The Heat's On

precisely . . . under the dependable control of Fenwal Standard Thermoswitch® Units

Key step in the manufacture of milk cartons on Pure-Pak carton-forming machines is the heat-sealing of the bottom flaps. For eight years this manufacturer has used Fenwal Series 17000 THERMOSWITCH units for temperature control of this vital operation. Result: eight years of precise troublefree control. *That's time-tested performance!*

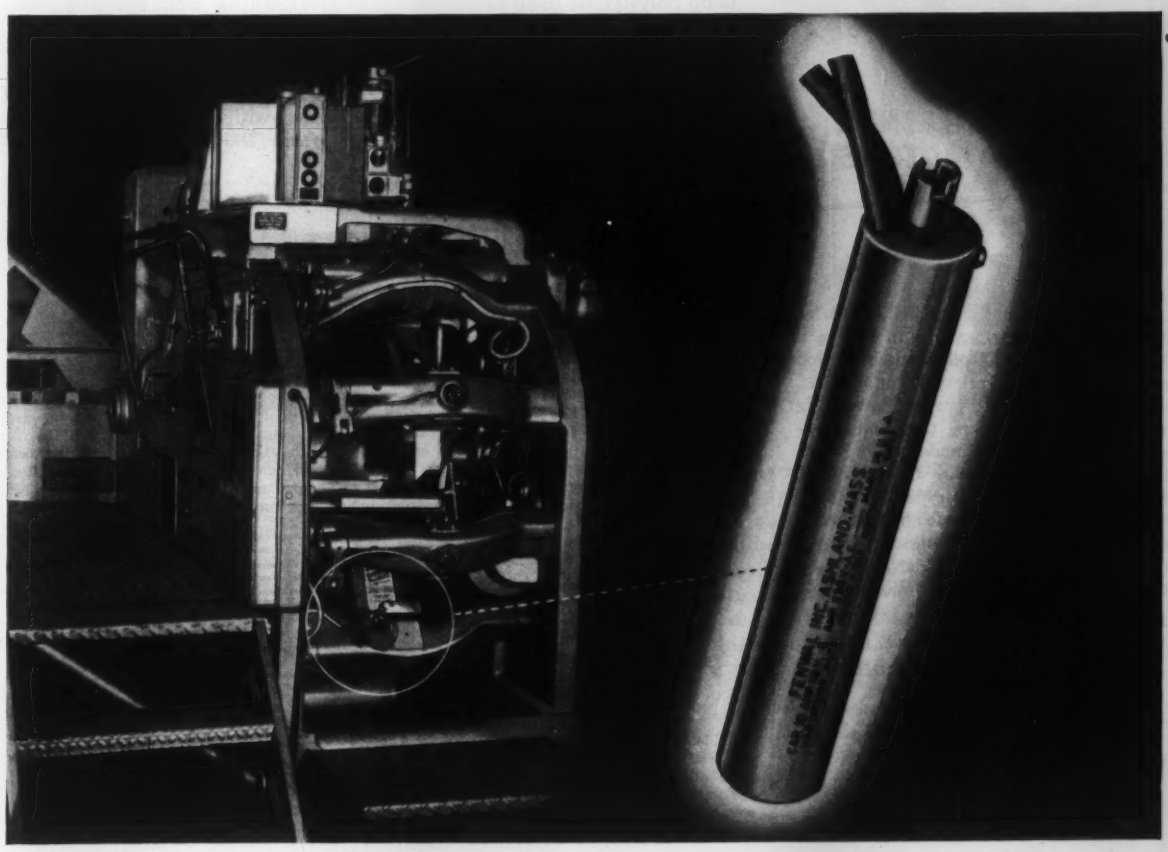
It's typical of the hundreds of successful installations of immersion and surface-mounted THERMOSWITCH units . . . in tanks, vats, air ducts . . . for widely varying space and position requirements . . . under the severest conditions of shock, vibration, and corrosion. *They're standard units with truly special capabilities!*

Yet for all their ruggedness, THERMOSWITCH units are sensitive to temperature changes of only a fraction of a degree. Heat sensitive outer shell responds instantly and accurately. *No thermal lag . . . no control error!*

Use these versatile units for control applications from −100 to +1100°F. They're completely adjustable with current ratings up to 10A-115VAC.

For complete details, write Fenwal Incorporated, 197 Pleasant Street, Ashland, Mass.

Compact, totally-enclosed Fenwal THERMOSWITCH units provide positive, service-free control of heat-sealing operation on this Pure-Pak carton-forming machine.



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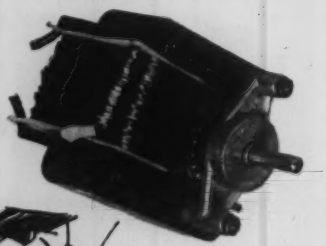
IS FOR PROFIT



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P MOTORS

You profit from exceptional low price and trouble-free performance in Heinze P Motors. These single coil 2 pole induction motors have a wide variety of applications, including pumps, fans, projectors, vending machines, space heaters, toys and appliances. Seven standard models have horsepower ratings of 1/500, 1/375, 1/250, 1/150, 1/100, 1/80 and 1/50 — for continuous duty. They provide slightly better ratings for intermittent duty. Free speed is 3400 rpm. Voltage is 115 or 220, 50/60 cycle. Rotation is CW or CCW.

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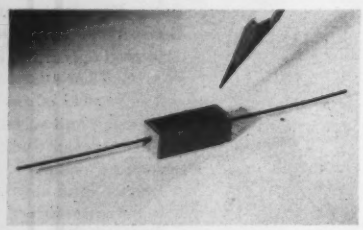
Circle 520 on Page 19



ance, and resistance required. Range of resistance is from 0.27 through 4700 ohms. Made in a rectangular shape, unit is 5/16 in. high x 5/16 in. wide x 7/8 in. long, with 1½-in. tinned copper axial leads. Resistor is highly resistant to humidity. **Hamilton - Hall Resistor Corp.**, 227 N. Water St., Milwaukee 2, Wis. K

Circle 669 on Page 19

Adhesives

bond polystyrene foam to various materials

Two adhesives are available for use in bonding polystyrene, one for foamed-in-place polystyrene applications and the other for bonding prefoamed polystyrene. A-827-B adhesive is suitable for use with foamed-in-place polystyrene. Assemblies withstand immersion in water at 120 F, hot-water spray at 160 F, dry-air heat at 160 F, and storage at −40 F. R-1083-T adhesive is used for bonding prefoamed polystyrene shapes to themselves, to polystyrene sheet, or to steel, aluminum, Transite, Formica, and other materials. Adhesive has no noticeable stress-crazing effect on polystyrene. Bonds withstand repeated simulated weathering cycles at temperatures from −40 to 160 F, plus water immersion and salt-spray environment. **B. F. Goodrich Industrial Products Co., Div., B. F. Goodrich Co.**, Akron, Ohio. F

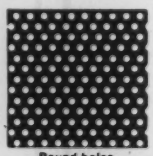
Circle 670 on Page 19

Gear Drives

have 780 to 1.2 rpm outputs at 1750 rpm input speed

Enclosed gear drives meet majority of application requirements for speed-reduction units of 125 hp and smaller, with output speeds ranging from 780 to 1.2 rpm at 1750

LET H&K PERFORATED MATERIALS
put personality into your products

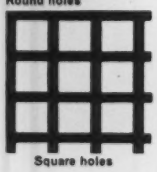


Whenever—wherever—your products require perforated materials, you will find the pattern and open area "just right" for that custom-look in the vast selection of H & K existing dies.

Modern facilities and H & K experienced craftsmanship, enable the perforating of practically all metals, wood, compositions and plastic. Perforated materials can be furnished in sheets, coils, rolls or plates. Fabricating services include shearing, rolling, welding and forming.

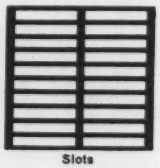
Illustrations shown in reduced size

Round holes



Square holes

Herringbones



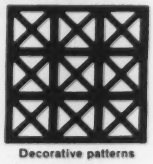
Slots

Oblong holes

Functional or Decorative Uses

H & K fills every need for perforated materials. Appropriate perforated metals can be ordered with color anodized, brushed and lacquered, painted, chrome plated, baked-on, or other special finishes.

Many patterns in steel sheets (industrial or decorative) are in stock at our warehouses. Send for H & K Stock List Brochure.



Decorative patterns

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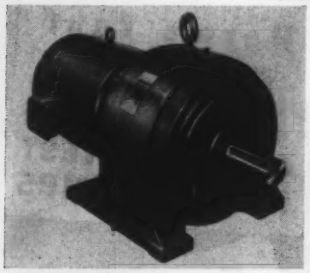
Listed Under "Perforated Metals"

Circle 521 on Page 19

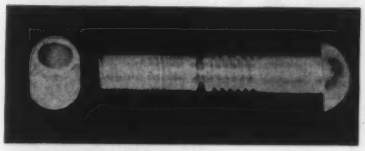


rpm input speed. Drives are rated in accordance with all applicable standards of AGMA. Heat-treated helical gears give high capacity, high shock resistance, and extra wear life. Foot-mounted, flange-mounted, and extended flange, straight-line units are available as integral-type gear motors, with motor and speed reducer forming an integral assembly, as all-motor-type gear motors, with standard motor coupled to input shaft of speed reducer, and as separate speed reducer units. **Wagner Electric Corp.**, 6400 Plymouth Ave., St. Louis 14, Mo. I

Circle 671 on Page 19

Fasteners

are available in larger diameters



Addition of Huckbolt fasteners in $\frac{5}{8}$ and $\frac{3}{4}$-in. nominal pin diameters extends line to cover size range from 3/16 to $\frac{3}{4}$ in. New fastener sizes are produced in 2024 aluminum alloy, AISI 1038 mild steel, and 300-series stainless steel. New tooling for installing the fasteners includes Model 504 and Model 505 hydraulic installation tools, and Model 905 Powerig, a portable hydraulic-power unit. **Huck Mfg. Co.**, 2480 Bellevue Ave., Detroit 7, Mich. H

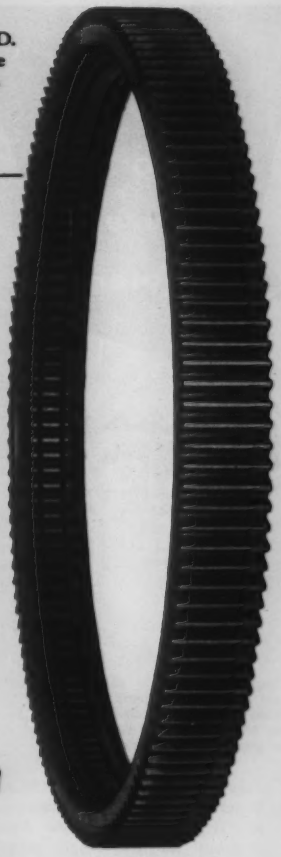
Circle 672 on Page 19

Toggle Switch

measures only $\frac{1}{2}$ x $\frac{1}{2}$ in. at base

Miniaturized two-position toggle switch provides dependable operation in temperature range of −65

Snap-ring grooves in this 12″ O. D. thin-section *Reduction Drive Gear* are machined before carborizing and hardening. Both spline and gear teeth are ground and held to .001″ excentricity after hardening the entire gear.



When you

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for profits,

GEAR

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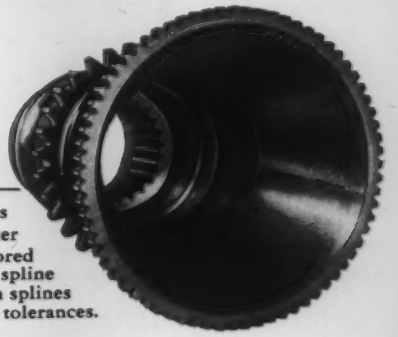
MACHINE AND GEAR CO.

Dept. 83 West Springfield, Mass.

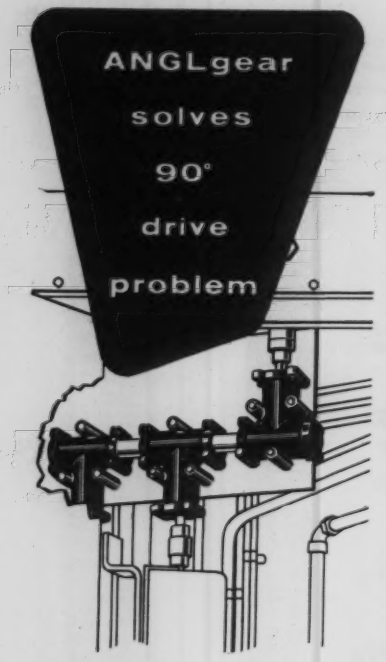
Men who *know* will tell you that custom precision gears made by Perkins can eliminate many design, production and maintenance headaches — literally help you drive for better profits. When you want precision gears in experimental or production quantities, chances are you'll save time and money by checking with Perkins first. What is your gear problem today?

This Handy Gear Calculator, **easy to use, saves time. *Folder*** **illustrating Perkins custom precision gears and facilities offers information. Both yours on request.**



Most machining operations on this *Drive Gear Shaft* **are performed after localized hardening with the cored areas at Rockwell C42. External spline and gear teeth are ground with splines held to precision tolerances.**

Circle 522 on Page 19



Simplified drawing, based on photo, shows ANGLgear installation on Cleveland Punch and Shear Works Co. power press. Compact, universal-mounting ANGLgears provide safe, positive 90° drive for press limit-control switches.

Cleveland Punch and Shear Works Co. engineers selected ANGLgears to actuate limit switches on Cleveland punch presses for these reasons:

First, it was essential to have direct-connected, lagfree control of press stroke to eliminate any chance of over-runs and consequent injury to operators and expensive dies. Second, the necessary right-angle drives had to be extremely compact, easy to install, and virtually maintenance-free.

ANGLgear met these specifications and Cleveland has continued to purchase the unit.

If you have a 90° power take-off problem, investigate ANGLgear. Completely enclosed, permanently lubricated ANGLgears are available from stock in ⅓, 1, 2¼ and 5 hp ratings, with 2 or 3-way shafting, and 1:1 or 2:1 gearing.

See our literature in Sweet's product design file; then contact your local distributor or write direct.

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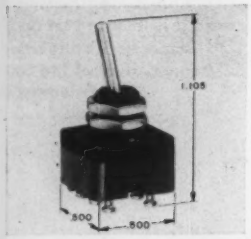
Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY

Circle 523 on Page 19

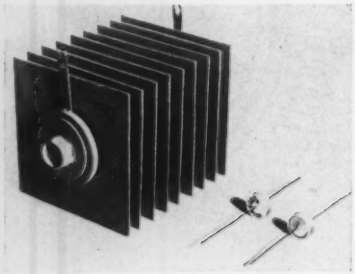


to +200 F. Switch, 2TM1-T, measures only ½ x ½ in. at base and weighs 4½ gm. Integral terminals, gold-plated stationary contacts, and high contact force provide low circuit resistance. Applications include use on aircraft panels and survival kits, geophysical equipment, printed-circuit and transistorized devices, and portable communication gear. Contact arrangement is DPDT, and electrical rating is 7 amp resistive, at sea level and 75,000 ft. **Micro Switch Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill. K

Circle 673 on Page 19

Silicon Rectifier

wafer-type unit provides high current in small space



Used in the manufacture of radio receivers, television sets, phonographs, tape recorders, sound-movie projectors, and electronic instruments, wafer-type silicon rectifier, called No. 40E5, is an epoxy-ceramic-encapsulated silicon diode. Unit provides high current in small space, does not short, is rugged and reliable, and withstands very high temperatures. Rectifier handles 750 ma with resistive load. It has a rating of 500 ma with capacitive load and peak inverse rating of 400 v. Old unit of comparable rating is shown at left. **Silicon Rectifier Div., Audio Devices Inc.**, 620 E. Dyer Rd., Santa Ana, Calif. L

Circle 674 on Page 19

Here's Your ABC's ON THE NEWEST ROTARY PUMPS

A SERIES LOW TO MEDIUM VISCOSITY

High speed units to pump 3 to 25 gpm . . . low speed units 20 to 97 gpm. Maximum operating pressures to 100 psi. Gear, V-Belt or direct drives.

B SERIES HAZARDOUS LIQUIDS

Sealed units U. L. Approved. High speed pump up to 23½ gpm . . . low speed pump to 90 gpm. Maximum U.L. pressure rating for hazardous fluids 50 psi. Gear, V-Belt or direct drives.

C SERIES RUGGED DUTY MEDIUM-HIGH VISCOSITY

Continuous operation Packed pumps. Heavy outboard thrust bearing. Pump up to 211 gpm at pressures to 125 psi. Gear, V-Belt and direct drives. Threaded or flanged ports. Also Series "E" steamjacketed pumps.

D SERIES RUGGED DUTY MECHANICALLY SEALED

For broad group of liquids of wide viscosity range. Pump up to 211 gpm @ 450 RPM. May be operated at pressures to 100 psi. Gear or gear-motor drives. Threaded or flanged ports.

Wayne PUMPS

THE WAYNE PUMP COMPANY
Industrial Division
FORT WAYNE 4, Indiana
Division of Symington Wayne Corporation

Circle 524 on Page 19

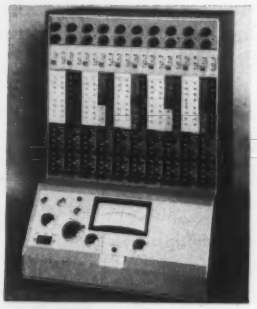
ENGINEERING DEPARTMENT

EQUIPMENT

Analog Computer

transistorized unit has high reliability

Low-cost analog computer is capable of performing 95 per cent of routine mathematical operations encountered in normal design calculations. Known as Pace TR-10, unit is 15 in. wide, 17 in. deep, and 24 in. high; it weighs only 80 lb without accessories. Use of transis-



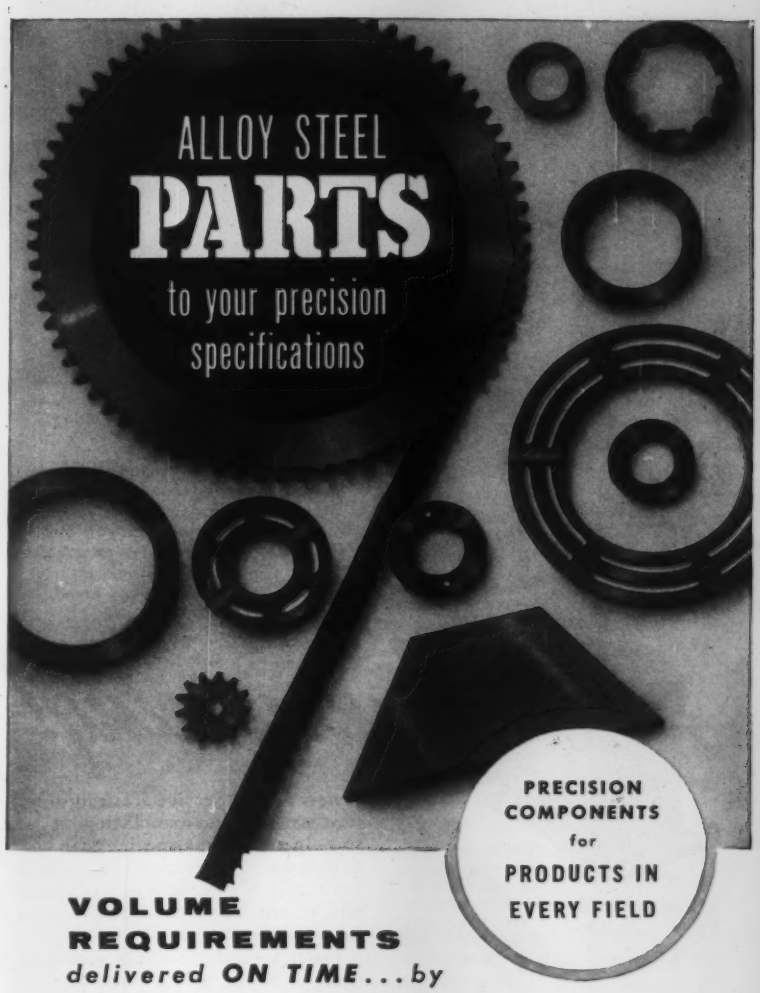
torized dc amplifier permits compact size, reliability, and 0.1 per cent accuracy. **Electronic Associates Inc.**, Long Branch, N. J. D

Circle 675 on Page 19

Drafting Machine

for use on any board at any angle

Neoglide drafting machine is designed for use on any board at any angle without need of adjustment. Enclosed counterweight unit provides positive counterbalancing at all board angles from horizontal to vertical. Head responds immediately to light index-finger pressure. Reinforced U-beam construction offers rigidity, strength, and accuracy while retaining clear, simple design. All components are assemblied within U-beam channel, protected from accidental damage or exposure to dust and dirt. Major moving parts are equipped with nylon wheels that ride on rigid hidden tracks. Protractor head operates on touch-control method for angle se-



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Call on ATKINS' complete production facilities and more than 100 years' design and manufacturing experience to supply *flat alloy-steel* parts for your product.

ATKINS will produce parts of any size or hardness, machined to any desired finish or tolerance . . . for automotive, aircraft or industrial engines and frames . . . machinery, presses and many other items of equipment. Typical ATKINS parts are clutch plates, valve discs, torsion bars and springs; flat steel machine parts; bars, spacer rings and washers; discs, knives and blades for any cutting or scraping operation.

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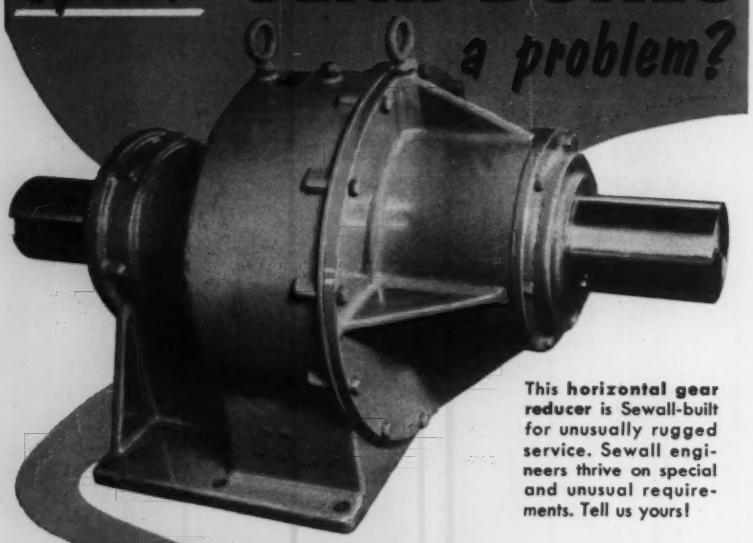
Our SECOND CENTURY of Service to American Industry

Circle 525 on Page 19

Special GEAR BOXES a problem?



This horizontal gear reducer is Sewall-built for unusually rugged service. Sewall engineers thrive on special and unusual requirements. Tell us yours!

Announcing!

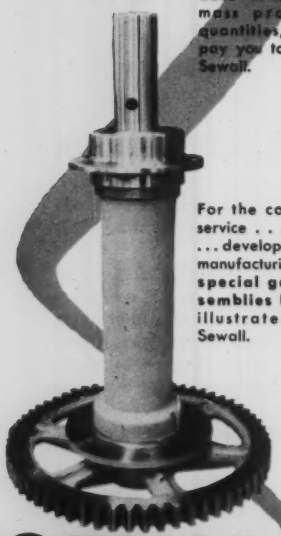
A new Sewall Service . . . designing, development and manufacturing . . . to help solve your special gear box problems . . . effectively . . . economically. We're ready to work with you at any stage of your project's development.

From scratch . . . our gear box designers will go to work for you right now. Give us a rough outline of your idea. We're staffed and equipped to design and manufacture gear boxes whatever the size and description of your requirements.

To your specifications . . . let us submit our quotation on producing your order in strict accordance with your prints. Sewall gear boxes are made by men who are fussy about specifications. Your order must be delivered as scheduled . . . priced right. Let us hear from you!

Sewall's complete gear service can help you . . . custom made gears . . . made-to-order sprockets . . . special gear racks—to order . . . standard gear racks in stock.

Whether you need gear boxes such as this worm gear reducer in custom or mass produced quantities, it will pay you to talk to Sewall.

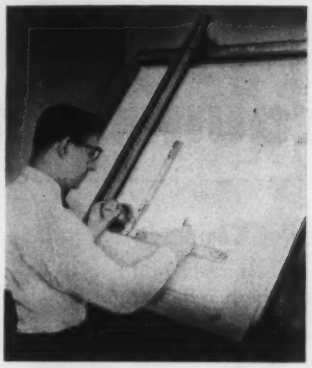


For the complete service . . . design . . . development . . . manufacturing . . . on special gear assemblies (sample illustrated) call Sewall.

SEWALL GEARS

E. B. SEWALL MANUFACTURING COMPANY

705 Raymond Avenue, Dept. A, ST. PAUL 14, MINNESOTA, Midway 5-7721



lection. Machine is easily raised to any height off board, and beam can be lowered into same position from which it was raised without disturbing settings. Unit fits all standard board sizes, with others available on special order. **Charles Bruning Co.**, 1800 W. Central Rd., Mt. Prospect, Ill. J

Circle 676 on Page 19

Diazo-Type Intermediate

contains nonreproducible phantom blue images

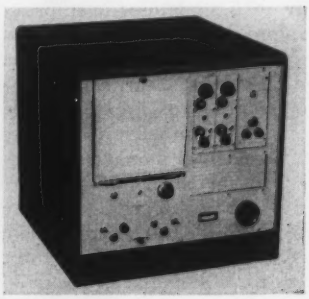
Easily readable phantom blue images on 206 PBT prints do not block actinic light and will not reproduce. Pencil or ink lines subsequently drawn in over blue lines do reproduce. The diazo-type intermediate paper has a variety of uses. **Frederick Post Co.**, Box 803, Chicago 90, Ill. J

Circle 677 on Page 19

X-Y Recorder

has high writing speeds

Model 670 X-Y recorder makes possible fast, accurate recording of families of transistor curves, or of rapid mechanical displacement, velocity, and acceleration. Traces are made by an ultraviolet light beam



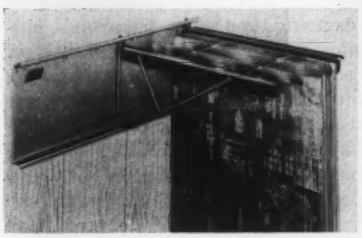
on 8 x 8-in. charts, loaded behind hinged front panel monitoring screen. Writing speeds in excess of 2500 ips can be attained with unit. Over-all frequency response is 3 db down at 130 cps and is independent of amplitude. Linearity is 1 per cent of full scale. Unit can be housed in portable case or rack mounted. **Industrial Div., Sanborn Co.**, 175 Wyman St., Waltham 54, Mass. B

Circle 678 on Page 19

Vertical File

holds 150 single sheets per linear foot

Redesigned vertical file combines advantages of vertical filing with convenience of handling only one sheet at a time. It permits filing 150 individual sheets up to 42 in. wide in one linear foot. Each sheet



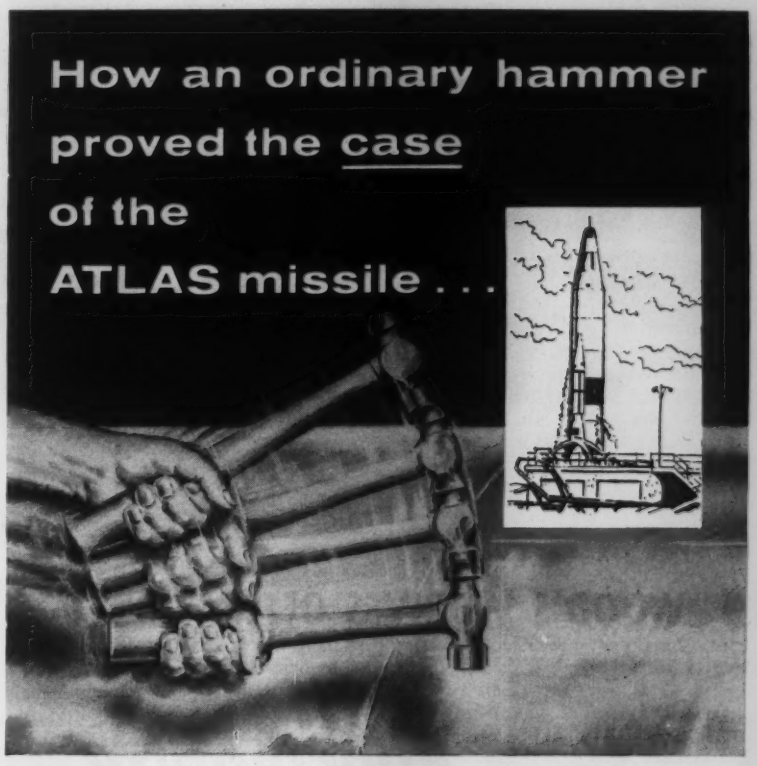
is attached to an aluminum hanger with aluminum foil adhesive fasteners. Hanger is notched to fit a rack which can be mounted on wall at height determined by length of sheets to be filed. Once inserted in rack, hanger cannot be jarred loose, yet is easily inserted or withdrawn. **Plan Hold Corp.**, 5202 Chakemco St., South Gate, Calif. L

Circle 679 on Page 19

Portable Photocopier

handles papers and films to 9 in. wide

Nine-inch portable photocopier can be used in diffusion transfer or single-sheet, multiple-copy process. It handles papers and films up to 9 in. wide in any length. Plastic container of ready-mixed solution fits inside hinged lid at rear of machine. Unit has built-in compartments for negative and positive papers or film. It is especially suitable for use with transfer papers, when used under fluorescent lighting or diffused daylight. Machine



The body of the missile, essentially one big fuel tank, is similar in principle to an inflated football. Convair-Astronautics broke new ground in missile design by developing a super-strong structure with a comparatively thin stainless steel skin to keep weight to a minimum. This stainless steel skin is so thin that the interior has to be pressurized to preserve the shape of the body as propellants are consumed in flight, or when the missile is being transported on the ground.

Some critics, however, thought the body was too fragile—"You could dent it with a hammer." So, recently, when the Scientific Advisory Board, engaged in a re-evaluation of all missile programs, arrived at Convair-Astronautics to take a reading on the ATLAS, they found that Convair had thoughtfully placed a number of hammers within easy reach of a finished missile. "Go ahead, bash it," invited Convair. The SAB members swung lustily. *Not a dent was registered*, for, although the walls are thin, the stainless has a minimum tensile strength of 200,000 psi.

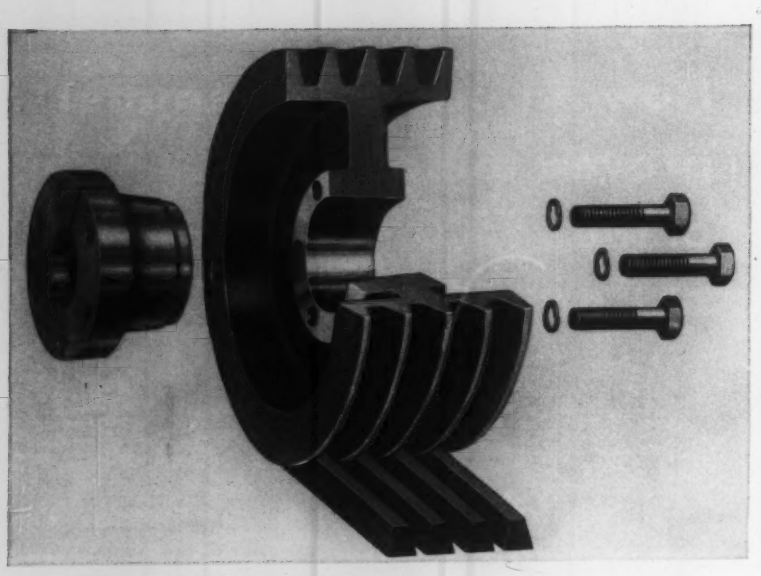
This stainless steel skin material, supplied by Washington Steel, required extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.

Stainless Steel—the Space Age Metal

Washington Steel Corporation

7-E Woodland Avenue
Washington, Pa.

Circle 527 on Page 19



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MOST WIDELY USED SHEAVE DESIGN . . . Wood's stock "Sure-Grip" sheaves are manufactured from sound, very high strength castings. Grooves are carefully machined to a fine finish to prolong belt life. Accurate balance assures maximum drive life. For sheaves of special design or materials (such as ductile iron), Wood's not only will manufacture to your specifications but, because of extensive pattern stocks and modern foundry facilities, may fill your needs at lower cost.

INTERCHANGEABLE BUSHINGS . . . Wood's "Sure-Grip" bushings are of the most universally used interchangeable type. They are easily and simply installed and removed.

MATCHED V-BELTS . . . Wood's "Sure-Grip" V-Belts incorporate the newest and strongest synthetic or steel cable tension members to assure highest carrying capacity and unequaled dimensional stability. They pull together regardless of number or size.

AVAILABILITY . . . Wood's offers one of the widest selections of standard and fractional horsepower types available from stock.

WRITE FOR CATALOG 197 (STANDARD HORSEPOWER) AND/OR CATALOG 799 (FRACTIONAL HORSEPOWER).

Wood's

T. B. WOOD'S SONS COMPANY
CHAMBERSBURG, PENNSYLVANIA

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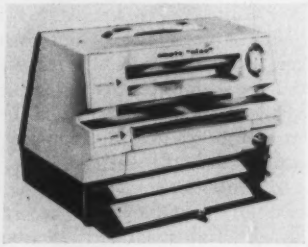
Circle 528 on Page 19



also makes positive films for use with positive plates for offset printing, diazo reproduction intermediates, and transparencies for visual (overhead) projectors. **Anken Chemical & Film Corp., Newton, N. J.** D

Circle 680 on Page 19

DC Power Supply

is high-efficiency, transistorized unit

New 400-cycle, ac-input, dc power supply utilizes a combination of magnetic amplifiers, transistors, silicon power rectifiers, and silicon zener diode to provide reliable, long life and excellent dynamic load regulation. The high-efficiency unit for laboratory use, Model M-1201, has transient regulation of ±10 per cent with step change of no load to full load or vice versa, and recovers to within 1 per cent of output voltage setting in less than 0.1 sec. Ripple is less than 0.05 v rms. AC input is 115/200 to 126/220 v, and dc output is 24.32 v at 25 amp. **Perkin Engineering Corp.**, 345 Kansas St., El Segundo, Calif. L

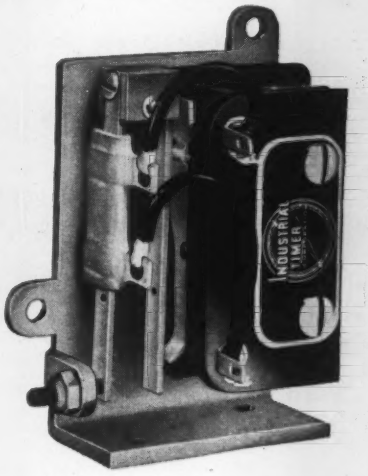
Circle 681 on Page 19

Drafting Tape

for printed-circuit layout

Self-sticking red plastic tape, precut to close-tolerance individual shapes for drawing printed-circuit masters, is designated B-225 See-Thru Red. Pressure-sensitive shapes are translucent, permitting layout over backlighted master grids. Tape surface is smooth, resolving light-bounce problems encountered in toplighting during photographic procedures. Tolerances of shapes are held to ±0.005 in., and thickness is 0.002 in. **W. H. Brady Co.**, 727 W. Glendale Ave., Milwaukee 9, Wis. K

Circle 682 on Page 19



These new developments are just two recent items added to our ever growing line of industrial timing devices which now exceeds 1,700 controls. If you would like more information about the line, drop us a note requesting our general catalogue.

NEW! MINIATURE THERMAL TIME DELAY SWITCH

10-20 Amp. Capacity—SNAP ACTION

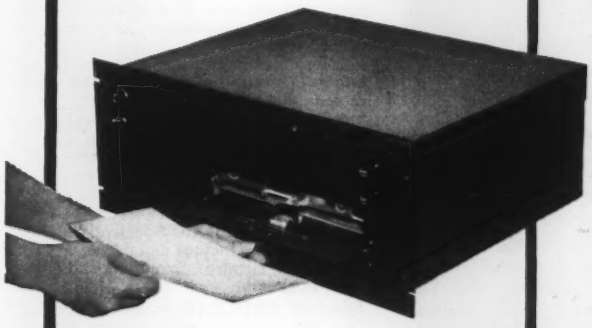
The new Series TH Timer makes accurate switching control of high current applications *practical* and *economical* for the first time! No more bulky, costly thermal switch and relay combinations . . . no more teasing of load contacts in electro-mechanical circuits from slow make-and-break. The new Series TH Timer's SNAP ACTION contacts give *fast, positive* switching of loads *up to 20 amperes.*

There's a wide choice of contacts, too: SPDT, Double Break, Magnetic Blowout DC and others to match your needs.

This new, compact timer automatically compensates for ambient temperature changes, by using two parallel bi-metal strips. Longer life comes from the rugged, totally enclosed cast ceramic heater. And you can adjust your time cycle easily with a single screw.

Available in time cycles from 15 seconds to 2 minutes, the new Series TH Timers are the low-cost answer to switching in air conditioning, refrigeration, exhaust and heater controls, computers, lighting, and a host of other applications.

For complete information, write today for Bulletin #900.



NEW! SIMPLIFIED PUNCHED CARD PROGRAMMER

Direct Control from Programmer to Process!

Here's the simple, dependable method of applying true automatic control to most of your manufacturing and operational processes . . . *direct control* of up to 85 individual load circuits through as many as 30 separate functions . . . with permanent, convenient 5" x 9" Mylar* punched cards.

Operation from any switch closure makes this electro-mechanical card reader easily adaptable to a variety of control systems, including analog, digital, temperature, feed-back, photoelectric, time and many others. Already in use for a wide variety of industrial and military applications, these flexible units are easily modified to meet your particular requirement.

For more information, write for Bulletin #100.

Timers that Control the Pulse Beat of Industry

AFFILIATE — LINE ELECTRIC COMPANY

INDUSTRIAL TIMER CORPORATION

1413 McCARTER HIGHWAY, NEWARK 4, N. J.

JUST a turn of the end on the adjusting rod and the stroke of this versatile O-M Cylinder is lengthened or shortened to fit the operation. This is accomplished with micrometer accuracy in a moment from the outside of the cylinder without disassembling or unmounting the unit or extra parts. Thus, you get the advantage of a special cylinder with no additional cost.

OTHER ADVANTAGES. Fits where others won't. All-steel construction with bearing surfaces of bronze. Designed right to seal right. Rod has high yield point. Can be disassembled and assembled faster than tie-rod types. Delivers continuous, smooth, dependable power at low or high speeds. Port can be oriented to any position. End plugs are tapped for universal mounting.

Available in a complete range of sizes (1½" to 8" bores) with standard, 2 to 1 or oversize rods. Also full line of mounting brackets interchangeable bore for bore. Immediate delivery on many sizes.

Mail coupon *TODAY* for Bulletin 112 featuring O-M Adjustable Stroke Air and Hydraulic Cylinders.

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City_____ Zone___ State_____

Circle 530 on Page 19

THE ENGINEER'S Library

Recent Books

Collective Bargaining as Viewed by Unorganized Engineers and Scientists. *By John W. Riegel, professor of industrial relations, University of Michigan; 105 pages, 6 by 9 in., clothbound; available from Publications Distribution Service, The University of Michigan, Ann Arbor, Michigan; $4.00 per copy.*

This report presents and discusses the responses of 264 nonsupervisory professionals to the question: "What is your opinion of collective bargaining for professional employees like yourself?" Professional society action was mentioned in several answers and is also discussed.

Employees of eight industrial companies and two public utilities were questioned. Engineers and scientists are not organized for collective bargaining in any of the ten companies. Interviewees worked in departments producing for consumer markets. Scientists interviewed included chemists, physicists, metallurgists, biochemists, biologists, and physicians. Also questioned were mechanical, electrical, chemical, civil, automotive, and electronic engineers.

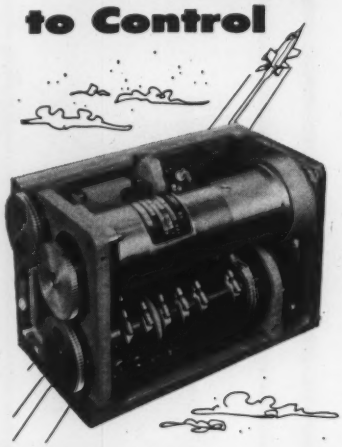
Applied Descriptive Geometry. *By Frank M. Warner, professor emeritus of general engineering, University of Washington, and Matthew McNeary, professor of engineering graphics, University of Maine; 243 pages, 6¼ by 9¼ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$5.25 per copy postpaid.*

Analysis and solution of three-dimensional problems are taught by using principles of orthographic, or multiview, projection. Point, line, and plane problems are solved by the auxiliary-view method. Other chapters discuss revolution, graphical manipulation of vectors, and curved lines and surfaces.

Definitions and theorems have been modified in this fifth edition. Additional subjects covered are visi-

SPECTROL PRECISION MECHANISMS

Pilot to Cockpit to Control



When a test pilot rockets into the outer atmosphere for the first time driving experimental craft such as North American's X-15, he'll feel as though he's been there before.

Before his first actual flight, the pilot trains for many hours in "dry land" rocket craft. There, he learns to cope with upper atmosphere problems as posed by an analog computer. Every time he touches a control, the computer responds and the result appears on the instrument panel in the training cockpit. The entire bank of instruments reacts as though he were really "up there." In this way, the pilot meets every conceivable situation long before he takes his powerful bird aloft.

And what does Spectrol have to do with this important training program?

Spectrol makes the link that joins the computer and the bank of instruments in the cockpit. This link, known as a servo repeater, translates the computer's information into meaningful dial readings. As you know, such information must be transferred quickly and accurately.

Spectrol servo repeaters do just that. Key specifications for a typical unit now in production are:

Maximum velocity: 360°/sec
Acceleration in excess of 7000°/sec²
Static accuracy better than 0.25 deg. at output shaft

Other applications for Spectrol packaged servo repeaters include dial drives on GCA equipment, airborne computers and dc systems in general.

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14

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ELECTRONICS CORPORATION
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Circle 531 on Page 19

bility, coplanar vectors, and fairing of complex double-curved surfaces.

New Standards

American Standard, ASA Y14.17-1959, Fluid Power Diagrams, American Drafting Standards Manual. *24 pages, 8½ by 11 in., paperbound, stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.50 per copy.*

Drafting procedures are outlined for drawings of fluid-power systems that use gas or liquid fluids within enclosed circuits. Explanatory notes and data which must usually accompany symbols and lines are explained in detail.

Four types of diagrams covered are pictorial, cutaway, graphic, and combination. Standard symbols for each type illustrate components, piping, power, capacity, and other ratings. Standard drafting practice is used for line conventions, lettering, sheet size, and title block.

Association Publications

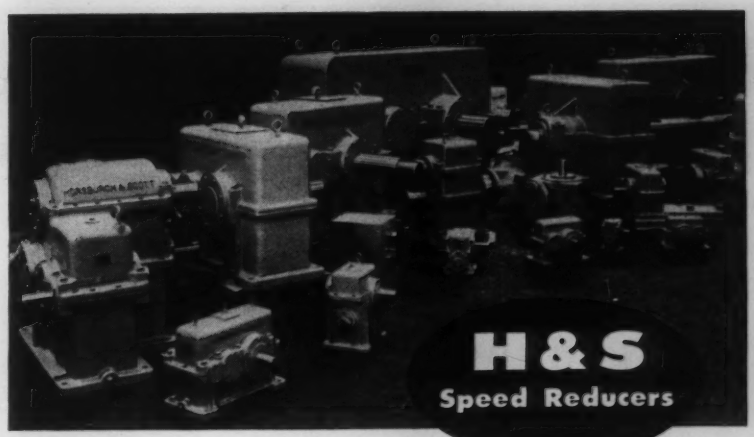
Symposium on Basic Mechanisms of Fatigue—STP 237. *121 pages, 6 by 9 in., clothbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $3.75 per copy.*

Six papers discuss fatigue damage caused by such mechanisms of failure as dislocations, internal friction, crystalline and structural changes, and surface disintegrations. Levels of observation used to define "basic" mechanisms are visual, microscopic, and hypothetical or submicroscopic. The statistical nature of material behavior under cyclic loadings is emphasized.

Government Publications

OTS Technical Report. *Copies of the report listed below are available from Office of Technical Servics, U. S. Dept. of Commerce, Washington 25, D. C.*

PB 151041, Reliability Prediction and Test Results on USAF Ground Electronic Equipment. By Joseph J. Naresky; 20 pages, 8 by 10¼ in., paperbound, side-stapled; $0.75 per copy. A technique is described which enables a designer to predict quantitative reliability of electronic equipment in the field. Application of the method to representative items of equipment, comparison of predicted figures with those obtained by laboratory and field tests, analysis of results and their usefulness, and recommendations for refining and improving the technique are discussed.



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Circle 532 on Page 19

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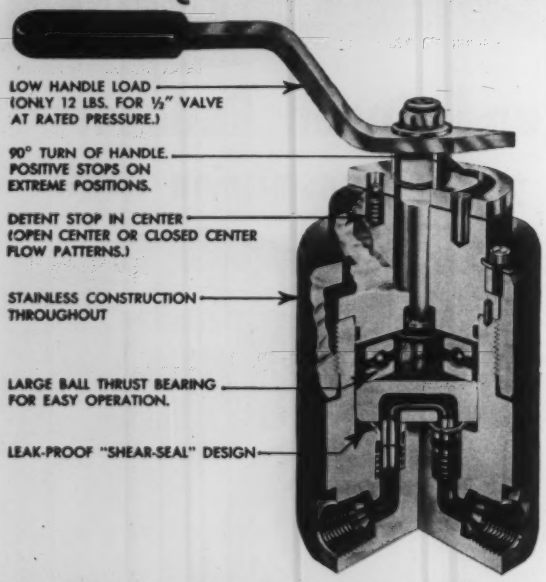
LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
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LARGE BALL THRUST BEARING FOR EASY OPERATION.
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CONTROL VALVE DIVISION **barksdale valves**

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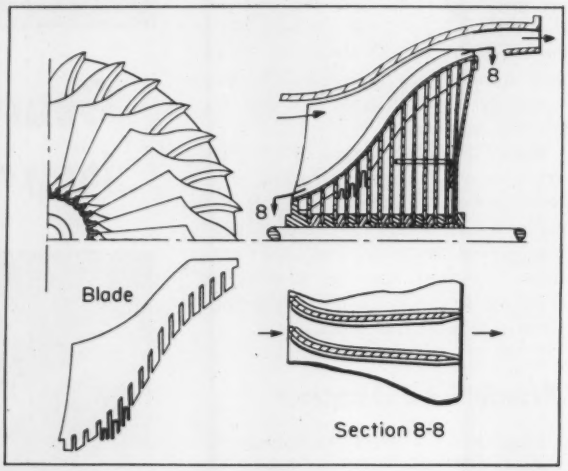
NOTEWORTHY

Patents

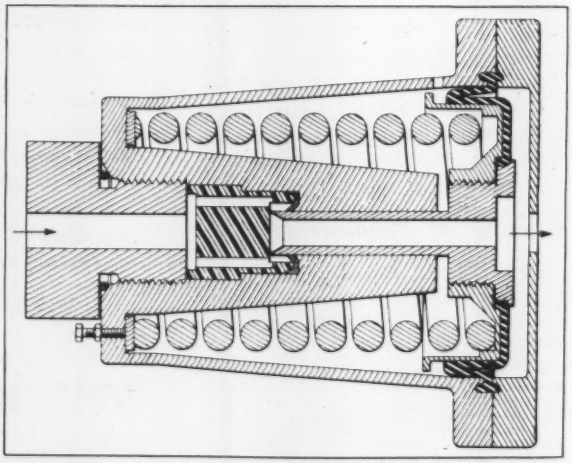
Built-Up Rotor Structure

In a high-speed pump rotor, high strength and light weight are achieved by built-up construction of steel plates. Rotor outside shape is determined by coaxial



discs spaced along their centers by hub elements, and on their peripheries by slotted blades. The blades are bent out of flat to form desired shapes of fluid channels. *Patent* 2,889,107 *assigned to the Stalker Corp., Bay City, Mich., by Edward A. Stalker.*

Sensitive Flow-Regulator



In a fluid-flow device, slight changes of outlet pressure cause proportionally small axial motion of a cylindrical core member against the force of a helical

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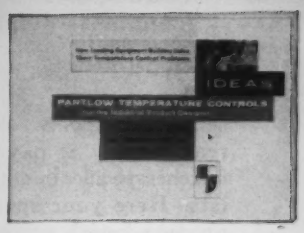

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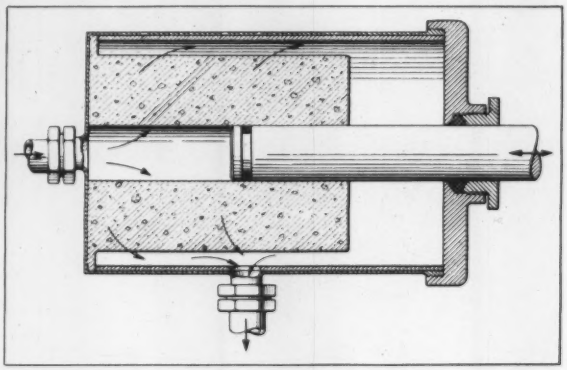
spring. The inlet end of the cylinder is flared to provide nearly line contact with a resilient plug. The plug passes fluid through holes on a diameter greater than the OD of the cylinder. Flow volume is adjusted by screws projecting outside the casing. At no flow—zero pressure differential—the spring holds the regulator fully open. *Patent 2,888,949, assigned to Robertshaw-Fulton Controls Co., Greensburg, Pa., by James R. Evans.*

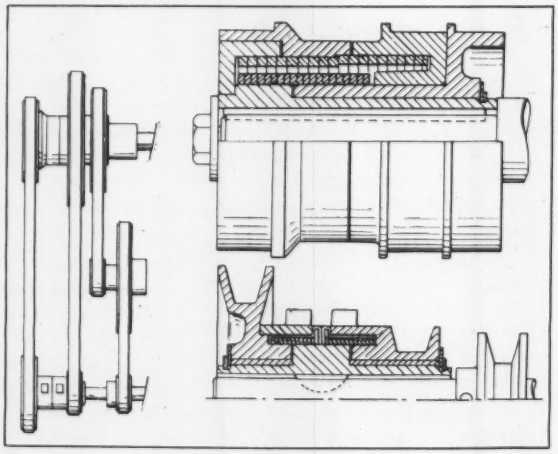
Fine-Control Fluid-Metering Device

Very close control of fluid flow is provided by a metering device in which functional parts are a porous body and a piston in the core of the porous member. Under pressure, inlet fluid fills the length of core not

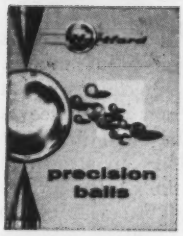


occupied by the piston, penetrates the porous material, and passes to outlet. Piston position, which is infinitely variable, determines rate of flow. *Patent 2,887,129 assigned to Hughes Aircraft Co., Culver City, Calif., by Edwin B. Stear.*

Three-Speed Pulley Drive



Stepped-diameter clutch springs in two multiple-pulley assemblies enable power transmission at any one of three different speed ratios. The driving assembly has one pulley pinned to the input shaft and two pulleys connected to the same shaft by pulley sleeves.



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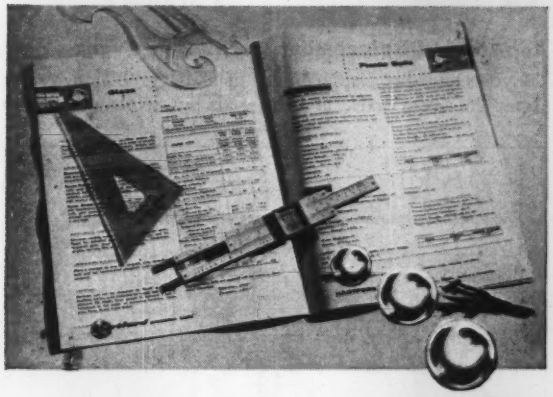

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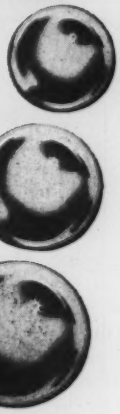

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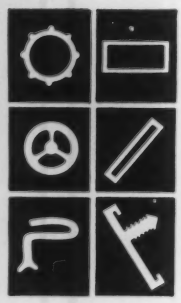

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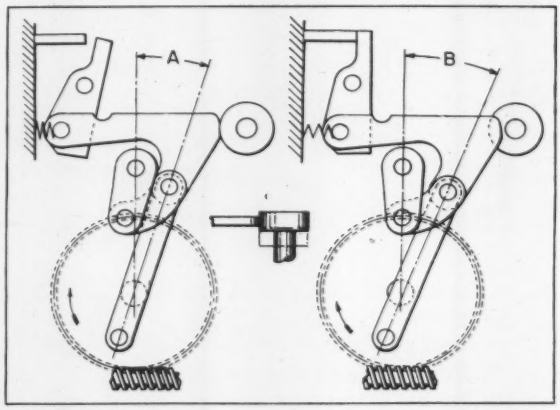
clutch springs, and a shaft sleeve. All driving pulleys have different diameters and rotate at input angular velocity. The two pulley sleeves have projections which are engaged by external stops. When both sleeves are stopped, the pulley pinned to the shaft drives at low speed. Release of either stop allows an associated pulley to drive at its characteristic ratio. Clutch springs in the driven assembly enable one of three pulleys to clutch the output shaft through intermediate members of the driven assembly. The same springs enable non-driven pulleys to idle. *Patent* 2,885,896 *assigned to Curtiss-Wright Corp., by Philip C. Hungerford and Donald R. Tomko.*

Adjustable-Displacement Oscillating Crank

Cyclic angular displacement of a short, straight crank about its fixed axis, is increased by displacement, to



the left, of a bell crank connected to the driving linkage. The bell crank is forced left, against a coil spring, when it contacts a roller raised into the plane of the linkage. The result, as shown in the drawing at left, is that a substantial angle is added at one end of travel of the oscillating crank. This angle can be discarded (drawing at right) by depressing the roller out of the linkage plane. *Patent* 2,880,621 *assigned to General Motors Corp., Detroit, by John B. Dyer and Walter D. Harrison.*

Directional Fluid-Flow Regulator

Depending on the setting of a threaded adjustment shaft, a floating ball closure blocks flow in one direction and permits unrestricted flow in the opposite direction. If the adjustment shaft is turned radially inward, it unseats the ball thereby permitting flow in the direction formerly blocked. To make sure that excess adjustment does not deform the ball, a threaded pin can be turned in to act as a positive limit stop. *Patent* 2,884,223 *assigned to General Gas Light Co., Kalamazoo, Mich., by Ralph D. Cocksley.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

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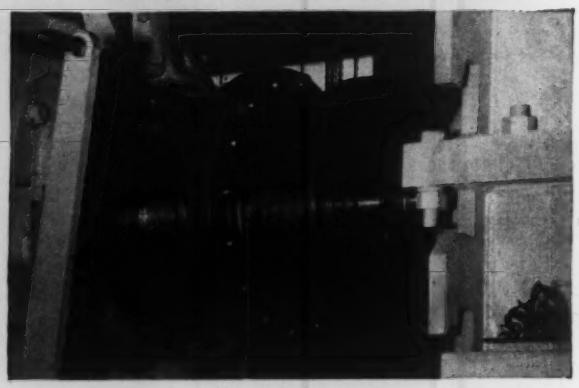

In the picture above is a Waldron #8 Cut-Out Coupling. It couples the power to a shearing machine, which takes mild steel strip from coil, straightens it and cuts it to lengths between 3' and 24' at the rate of 1250 feet per minute.

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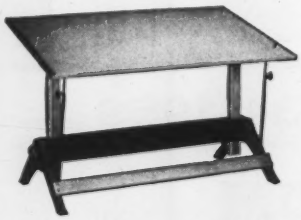

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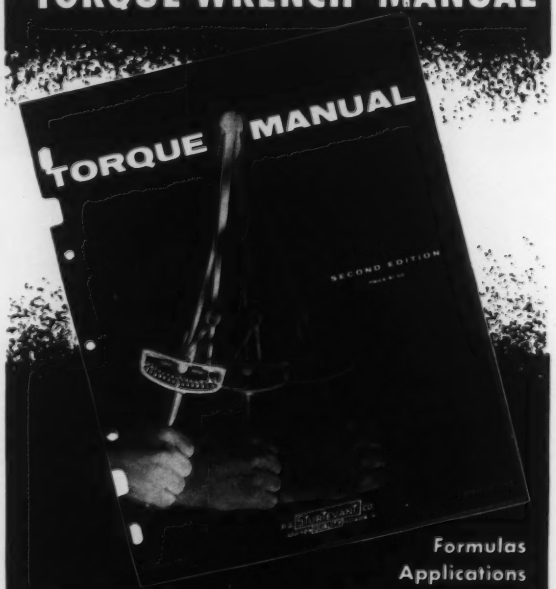

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POSSIBLE ONLY with a SIGMAMOTOR PUMP

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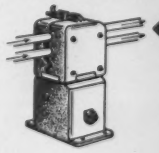
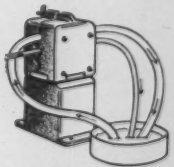
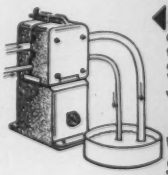
Material being pumped never comes in contact with pump mechanism. Wave-like motion of steel fingers forces material through Tygon tubing. By changing size of tubing, capacity can be increased or decreased. Pump housing opens for removal and insertion of tubing.



PUMP 2 OR 3 DIFFERENT LIQUIDS SIMULTANEOUSLY
Some models will accommodate up to four tubes so that four different liquids can be passed through the pump at one time without danger of contamination.

FEED AND MIX
One or more tubes can be feeding material to a mix while a larger tube is recirculating the liquid to produce agitation and thorough mixing. Viscous materials can be pumped without danger of gumming or plugging. Remove tube and pump is clean.





METER ADDITIVES
One or more additives can be pumped to a solution in the exact amount desired by selecting the correct size of tubing and regulating pump speed. Various controls can be incorporated to close valves ahead of pump.

Capacities from 0.5 cc. per min. to 4.5 G.P.M.

Write for complete information on sizes and capacities.

SIGMAMOTOR, INC.
26 N. Main Street • Middleport, N. Y.

Circle 547 on Page 19

Which Kind of SANDVIK SPRING PERFORMANCE Fits YOUR Product?

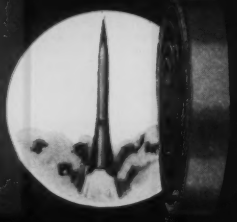
FOR ORDINARY SERVICE

Sandvik SPIRAL springs provide long-lived, low-cost service for starters, guard return springs, toys or tension devices where constant torque is not critical.

Sandvik CROSS-CURVED springs have a dual tension produced by winding the spring against both its tempered spiral and against a special convex curvature across the width of the strip. The longer, more even energy release provides uniform power for timing instruments, carriage return springs, movie cameras and other high performance applications.

Sandvik 2R25 stainless springs are a super quality which give 5 to 10 times longer performance than ordinary carbon steel springs and can take the corrosive attacks of varying atmospheres too. For applications where performance demand outranks cost, such as in missiles, aircraft and special instruments.

FOR ULTRA CRITICAL APPLICATIONS

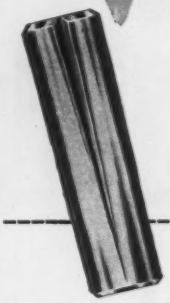


These examples give you some idea of Sandvik's ability to supply the spring that fits your application in both performance and cost. You can draw on Sandvik's fund of over 30 years of spring experience to help select or develop the exact size and type that's right for your product. Ask for further information or send us the data on your spring application.

SANDVIK STEEL, INC.
Fair Lawn, New Jersey
Tel. SWarthmore 7-6200
In New York City: Algonquin 5-2200
Cleveland • Chicago • Detroit • Los Angeles

have you checked

DRIV-LOK PIN *advantages?*



1. **Positive anchoring . . . once in they *stay in* . . . yet they're reusable**
2. **Stronger, safer, solid body**
3. **Quick installation . . . Lower Costs**

TYPICAL APPLICATIONS:

DRIV-LOK Pins are effecting great economies and product improvement in applications of every type. Easy to install — just drill the hole and press or drive them in. The job is done — no reaming, no expensive hole preparation. Available in carbon steel in 8 standard types; also a wide variety of special materials. Write us, describing your fastening requirements. Catalog and samples sent without obligation.

DRIV-LOK SALES CORPORATION
715 Park Avenue • Sycamore, Illinois

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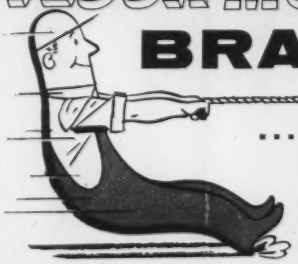
Stearns **ELECTRO-MAGNETIC DISC**

FLOOR MOUNTED BRAKES



. . . quietly stop individual shafts or motors — *fast*

. . . and keep both feet on the ground!

- ✓ Over 40 sizes from 1 to 575 lb ft max. torque in 6 compact, standard styles.
- ✓ Drip-proof, or waterproof enclosures.
- ✓ Fast, positive actuation.
- ✓ Installation-proved dependability.
- ✓ Faster, easier installation — attach directly to shafts of double-end motors without couplings.
- ✓ AC or DC operation.
- ✓ Exclusive Stearns "Visi-wear-indicator". ✓ Fully assembled.

For Superior Performance . . . Specify Stearns!
Request Bulletins 226-H and 3502-S

Stearns **ELECTRIC CORPORATION**
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN

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Circle 548 on Page 19

IMMEDIATE DELIVERY!

Motor Blower Assemblies!

Compact, rugged construction. In stock from 4 to 150 CFM. Designed for applications where space and weight are prime factors. Blowers available without motors.

Write for literature.

Superior ... through Research

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RIPLEY COMPANY INC.

MIDDLETOWN, CONNECTICUT

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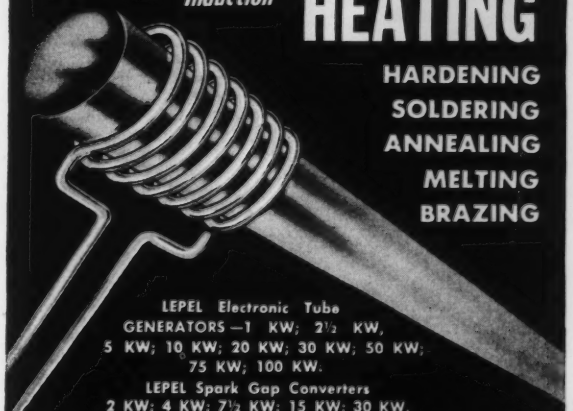
Lepel

HIGH FREQUENCY *Induction* HEATING



HARDENING
SOLDERING
ANNEALING
MELTING
BRAZING

LEPEL Electronic Tube GENERATORS—1 KW; 2½ KW, 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters
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WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

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55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

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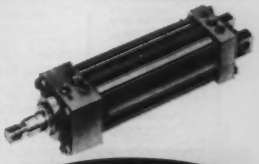
WHO'S SMILING?

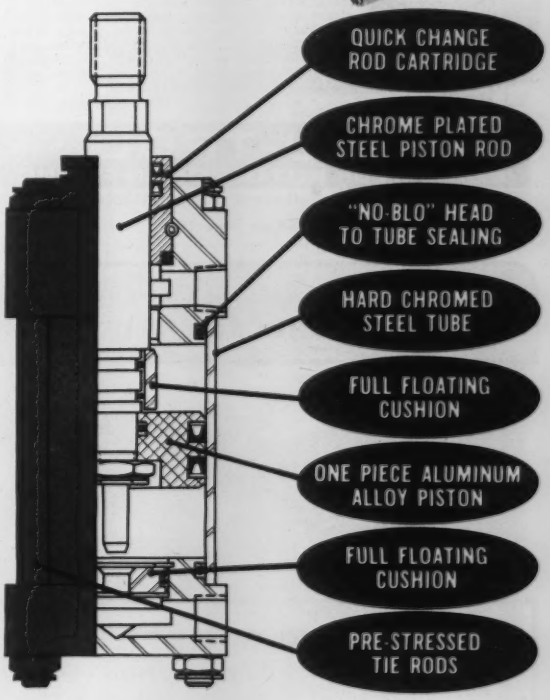
YOU, WHEN **YOU** DISCOVER THE DESIGN ADVANTAGES OF . . . .

LINDBERG

SQUAREHEAD CYLINDERS

DESIGN IN LINDBERG AND . . . ADD ALL THESE FEATURES!
and many more besides!

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CERTAINLY! Your choice of mounting styles • 7 bore sizes to 6" • Built to JIC recommendations • Standardized mounting dimensions.

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2000 PSI "H" LINE—	BULLETIN H-101
HEAVY DUTY "A" LINE—	BULLETIN A-101

for fast action on "specials" tell us what you need.

LINDBERG AIR and HYDRAULIC DIV.
TEER-WICKWIRE & CO.
1877 WILDWOOD AVE. • JACKSON, MICHIGAN

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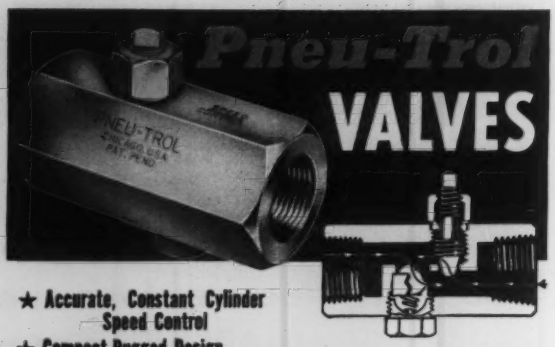
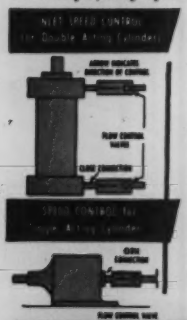
Pneu-Trol VALVES



★ Accurate, Constant Cylinder Speed Control
★ Compact Rugged Design
★ Simple, Easy Speed Selection ★ For Air, Oil or Water Applications



Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

Write for illustrated circular and prices.

PNEU-TROL
A DIVISION OF AUTO-PONENTS, INC.
2925 Grant Street • Bellwood, (Chicago Suburb) Illinois

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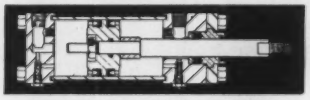
LYNAIR, Inc.

AIRLINE BOOSTER PUMP

Lynair's Airline Booster was developed to boost airline pressure automatically in surge tanks or die cushions. Can be used for testing vessels at high pressure under water. By using air pressure up to 500 PSI instead of hydraulic pressure testing time can sometimes be cut in half. Booster can be furnished in ratios of 1.5 to 1 up to 6.25 to 1. Booster is completely valved—just 3 pipe connections to be made and your air pressure is automatically increased to the desired pressure.



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1½" to 10" bores. Eleven mounting styles available. Steel heads, shells, piston rods and tie rods. Piston rod and shell hard chrome plated. Conform to J.I.C. pneumatic standards.

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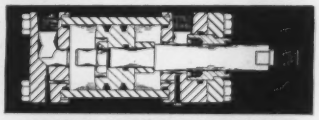

SERIES "H" 2000 PSI HYDRAULIC CYLINDER

We are presently seeking representation in several states, including Indiana, Kentucky, Minnesota, New Jersey, Tennessee, Washington and Wisconsin.

LYNAIR, Inc. 3100 E. MICHIGAN AVE. JACKSON, MICHIGAN

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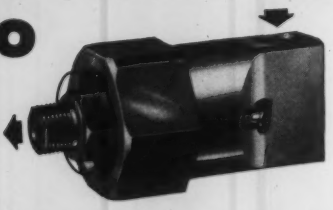
For High Speed Rotating Connections on
SPINDLES • CHUCKS • CLUTCHES

BARCO
NEW TYPE D REVOLVING JOINT



UP TO 10,000 RPM!

Use Barco's new TYPE D Revolving Joints wherever you need high speed, low torque, leakproof rotary connections for air, hydraulic, or coolant lines on clutches, machine tools and other equipment:

- **LIGHT RUNNING!** Ball bearing design for low torque and minimum wear.
- **LEAKPROOF!** Thanks to Barco's static O-ring seal.
- **PRECISION-BUILT!** All parts machined to close tolerances. Parts interchangeable and easily renewable.
- **COMPACT, DURABLE!** Easy to install where space is limited. Overall length, 3 13/16". Built for rugged service.
- **WIDE SPEED RANGE!** Up to 10,000 RPM. For pressures to 300 psi (air) or 3000 psi (hydraulic). Economical TYPE E available for up to 2,500 RPM. SEND FOR CATALOG SHEET 308.

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506H Hough Street • Barrington, Illinois

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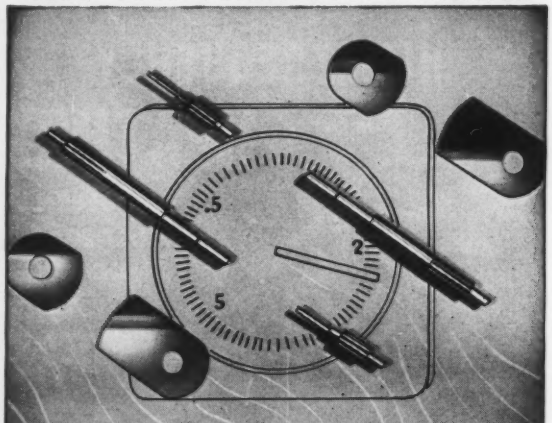
20 TO 200 D.P.

SEND YOUR PRINTS FOR QUOTATION



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STRAIGHT BEVELS • LEAD SCREWS • RATCHETS
CLUSTER GEARS • RACKS • INTERNALS • ODD SHAPES

THE *Finest* IN GEARS

Beaver Gear Works Inc.

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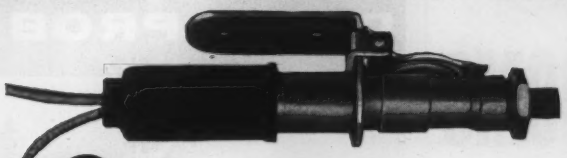
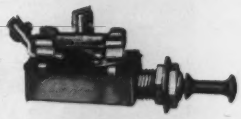
COLE-HERSEE *Switches & Connectors*



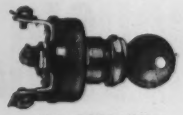
No. 1281 Heavy Duty Polarized Two Pole Electrical Connector (Insulated or Grounded)

No. 9524 Combination Rotary Ignition & Light Switch



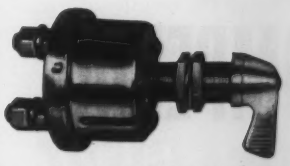
No. 5053 Push Pull Fused Light Switch

No. DL-5 Dash Lamp



No. 9522 Key Operated Ignition & Light Switch

Plastic-Coated Solenoid Completely Waterproofed Non-Breakable Intermittent Duty Solenoid



Master Disconnect Switches S.P.S.T. D.P.S.T. (Extra Heavy Capacity)

BUILT UP TO A STANDARD — NOT DOWN TO A PRICE

COLE-HERSEE COLE-HERSEE CO.

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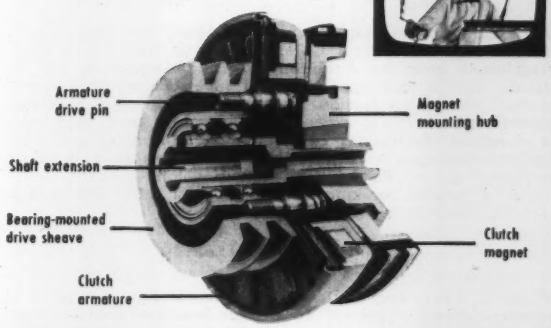
new...electric clutch-pulley package



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Modernizes machine drives and controls—fits all standard NEMA motors. Direct, low-cost method of converting to fully automatic or remote control. Fastest way to cycle a machine drive, with motor running continuously. Operates at any speed. Reduces motor wear and power consumption. Smooth, *adjustable* acceleration. Simple to install. Five sizes, from 1 to 25 hp, available off-the-shelf from all Warner distributors. Write for Bulletin P-52.

WARNER **Warner Electric Brake & Clutch Co.**
Beloit, Wisconsin

Circle 559 on Page 19

The Proof of the Drawing is in the Prints

DAMASCUS does the job better

Make this test. Compare the **prints** from drawings made by your present pencil and Damascus Drawing. Look for broken lines, light spots, uneven line edges. You will agree that Damascus gives you sharper, blacker **prints**—as **good as your drawings**. Reproduces beautifully on **MYLAR**.

Send for free sample kit of Damascus Drawing pencils. Or ask the man who knows—**Your Blueprinter.**

R B **Richard Best Pencil Company**
Springfield, New Jersey

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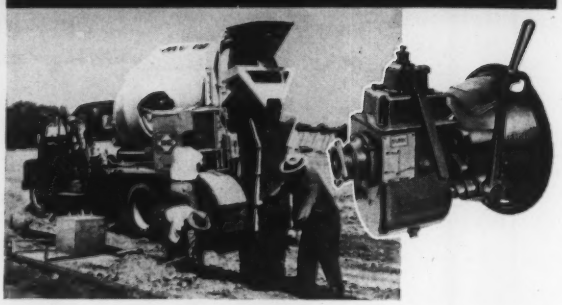
THE TREND IN DRAFTING ROOMS THROUGHOUT THE WORLD IS TOWARD IMPERIAL, THE WORLD'S FINEST TRACING CLOTH

Circle 561 on Page 19

FUNK LICKED THIS DRIVE PROBLEM



On this Blaw-Knox truck mixer, FUNK-designed units handle an unusual job in a simple way. Speed and flexibility were gained with a 3-speed synchro-mesh transmission having overdrive and underdrive. A space and alignment problem was solved by the unique design of the heavy-duty clutch case that enables the transmission to be offset at a 20° angle.

Another example of how FUNK MODULAR POWER UNITS can solve hard power problems — easily and economically! Let FUNK help you!

FUNK MFG. CO. Box 577-F COFFEYVILLE, KANSAS

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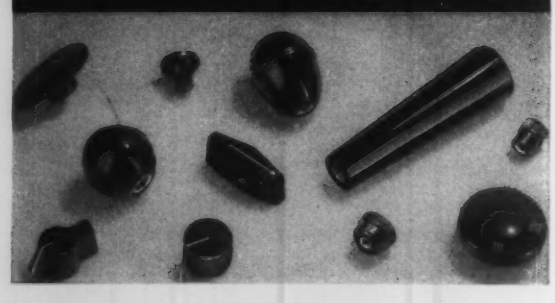
DIMCO-GRAY *Stock plastic* KNOBS...HANDLES



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NO TOOL CHARGE!

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DIMCO-GRAY COMPANY

204 EAST SIXTH STREET—DAYTON 2, OHIO

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ENGINEERS AVAILABLE OR WANTED

WANTED: Specialized Machine Designer for employment with a major Chemical Company in the Gulf Coast area. Applicants must be qualified and experienced in the intricate design and application of reciprocating and rotary motion, energy conversion, and plastic extrusion. A thorough knowledge of metallurgy, thermodynamics and harmonics is essential. Additional experience in equipment manufacturing techniques is very desirable. Send resume and salary requirements to: P. O. Box 8802S, Houston 4, Texas. Interviews arranged for qualified applicants only. All replies will be held in strict confidence.

Wanted: Experienced Design Engineers. Imagination and resourcefulness required. To design machine parts, assemblies, or complete machines, working in conjunction with a Research Engineer or Development Engineer. Must have imagination, and enjoy working on a drawing board. Must be able to supervise erectors or other assistants, and conduct laboratory or field trials of machinery designed. Must be graduate Mechanical Engineer, with at least five years experience in the machine design field. Experience with textile machinery helpful, but not essential. South Carolina location. Positions available for those who can qualify by experience and interest about August 1, with interviews being held during July. Write, giving full information of educational background, work experience, and earnings, as well as personal information of interest. All replies will be held confidential. Our employees know about this ad. Address Box 946, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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Main 1-8260

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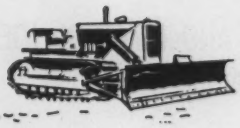

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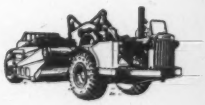

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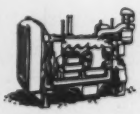

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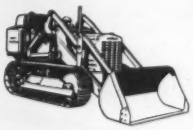

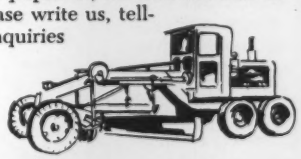

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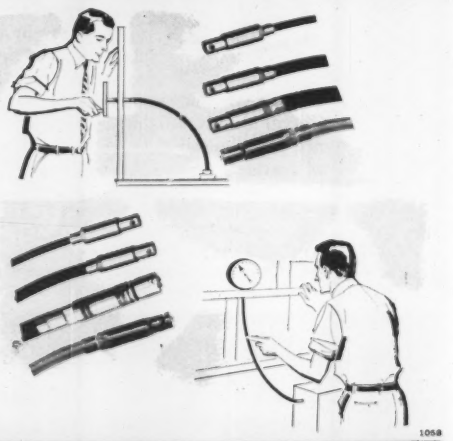

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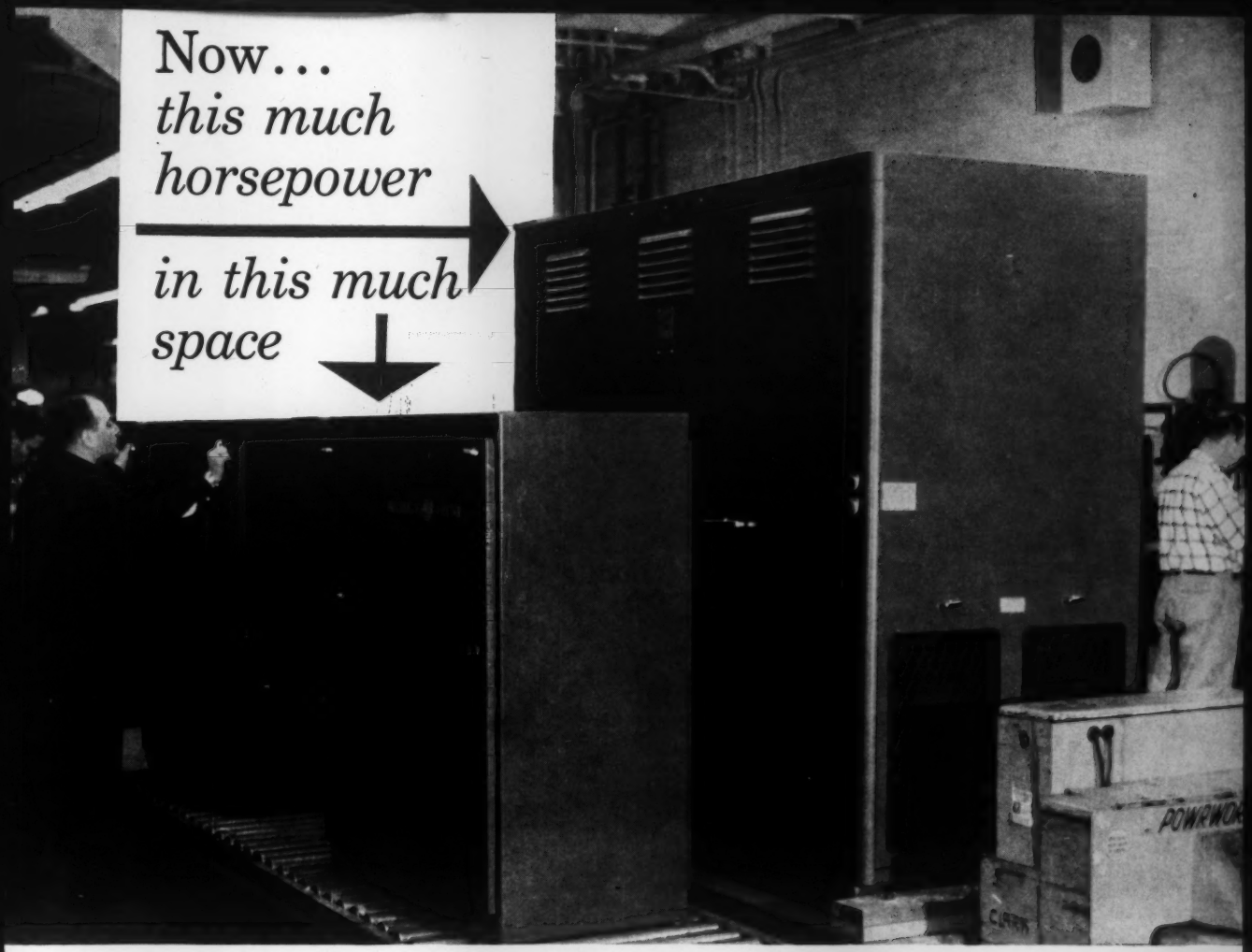

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